

The summer of 1985 turned out to be the hottest on record for Tulsa, Oklahoma, and that day in July was sure to live in the town's history books. Two boys were playing outside while their mothers were inside preparing lunch for their children. "The boys were outside for more than two hours, they must be hot and tired. Let's get them inside and have them watch TV after lunch; they can go back outside when it cools off." John has been talking about putting in a pool that will make these hot summers more bearable."

The women stopped talking when they heard someone tapping on the sliding glass door facing the back yard. "Mrs. Myron, Mrs. Myron, come quickly," someone called out.

"What's wrong, Jack?" asked Mrs. Myron as she opened the sliding door.

"Greg fell over and didn't get up," Jack said, as he and the two women ran over to a four-year-old boy lying next to the sand box.

"We were building a big castle in the sand box," Jack continued. "Greg wasn't happy because one of the towers fell in. He stood and went to jump on it, but he just fell over. I thought he was just playing, but he didn't get up."

The two women carried the limp boy into the house and lay him on the sofa. Mrs. Myron was placing a cool, wet cloth on her son's forehead when his eyes opened.

"What happened?" Greg asked.

"You passed out, again," replied his mother. "I noticed that you didn't touch the lemonade we left you boys."

"Do you think we should take him to hospital?" asked Mrs. Rose, Jack's mother.

"I'm afraid this isn't the first time this has happened," replied Mrs. Myron. She pinched the skin on the back of her son's hand and noticed that it did not spring back. "I think he's just dehydrated. He gets so immersed in what he's doing that he forgets to drink. It's my fault. It really is too hot, but he loves to play outside."

Greg started to get off the sofa, but quickly fell back.

"Mom, I'm feeling dizzy and I'm really thirsty. Can I have a glass of water?"

"Of course, my dear. I think you two will be staying inside this afternoon."

"But Mom..."

"I need to have you close by so I can keep an eye on you. Here, I'll turn on the TV."

### Questions

1. What signs and symptoms did Greg exhibit when he was in the house? *dizziness, skin did not spring back*
2. Was Mrs. Myron correct when she said that Greg was dehydrated? Which signs and symptoms are consistent with this notion? *yes, thirsty, dizziness, skin not springing back, thirsty*
3. Explain how each sign or symptom can be treated by dehydration. *skin loses elasticity over a twenty*
4. Mrs. Myron thought that it was not necessary to seek medical treatment. Do you think she was correct? *denied that*

*NO it is not normal to pass out frequently from dehydration by dehydration because blood volume goes down*

### Part II - The High School Football Game

It was a beautiful Saturday morning in October 1999. The weather in Tulsa, Oklahoma, was a balmy 92°F with 71% humidity. Greg woke up and went downstairs. He felt a little dizzy. "Wherever heard of having a team party the night before the State Championship?" he wondered to himself as he staggered into the kitchen.

"Your breakfast is ready; better hurry and eat or you'll be late!" Mrs. Myron put the plate of waffles on the table with a smile. "I'm not hungry Mom," Greg said as he pushed the plate to the center of the table. "Is coffee ready?"

"Oh, Gregory, it's probably just nerves for the game tonight. You really should try to eat something or you're going to fade by the third quarter. Here's some coffee and take this bagel and banana with you and eat them on the way."

Greg took the bagel and coffee and crested himself against the table as he stood up.

"Are you okay, Greg?" his mother asked him.

"Sure, just a little dizzy, probably got up too fast."

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Arriving in the parking lot he polished off the last of the coffee and left the bagel in the car - there was no time to eat, and he still wasn't feeling hungry anyway.

"Myron!" yelled the coach. "Had a little too much fun last night? I know this is only the pre-game warm up, but you look like you're dragging! Hope you're ready for tonight. We're counting on the school's star running back to lead us to victory!"

Greg removed his helmet. "Yes, sir!" he yelled enthusiastically, but he felt anything but.

"Good, grab some water; you're flushed and sweating like a pig. Or did you forget to wash off your dad's makeup?" mocked the coach.

it's 4 and 20 from their own 10. The Bulldogs have to go for it if they want to win this game," boomed the loudspeaker. Greg, after a kicklatter game so far, set up for what could be the last play of the season. It was a pitch back and Greg was off, running down the sideline. He sprinted down to the opposition's 20-yard line before taking a crunching hit from the free safety, which knocked him out of bounds in front of a stand full of screaming spectators.

"No time for another play," yelled the coach, yelling the game clock, which had stopped with less than a second to go.

Everyone stopped and there was silence on the field. Greg was lying motionless on the ground. His parents came out of the stands and rushed to the side line as the trainer ran across the field. The coach made a call and an ambulance drove out onto the field to take the seemingly unconscious player to the hospital. Greg came to as he felt the vehicle move under him. He could see his parents and heard the public address system over the ambulance's siren. "It's up and it's good. The Bulldogs win the 1999 state championship!"

Greg smiled and closed his eyes.

### Questions

1. What were Greg's signs and symptoms before the game and during the warm up? *dizziness, loss of appetite, passing out, sweating*
2. Can you think of any reasons why Greg exhibited these signs and symptoms? *drunk alcohol -> dehydrated*
3. Greg is taken to the hospital after being injured during the game. What problems do you think the physician will find with Greg when they examine him, or do you think he is only suffering from dehydration?
4. If you were a doctor in the Emergency Room, describe two tests you would run to determine Greg's problems. For each test, predict the results you would expect. *Test for glucose and salt content levels.*

### Part III - The Next Day in the Hospital

Greg woke up from a night's sleep with a jolt. He opened his eyes, he remembered that he was in the hospital. His parents stood beside the bed, and a stranger loomed over him.

"My name is Doctor Jenkins. The x-rays showed no broken bones. I am just looking at the results of the tests we did when you came in last night."

Test	Greg	Normal
Heart rate (beats/minute)	58	73
ECG	Normal	
Blood pressure	100/60	120/70
Time of urination	n/a	
Blood pH	7.38	7.35 - 7.45
Arterial $PO_2$	98	90 - 100
Electrolytes: $Na^+$	43	35 - 45
Electrolytes: $K^+$	3.9	3.5 - 5.2
Blood glucose	152	135 - 147
Cortisol (ug/dL)	65	60 - 110
ACTH (ng/mL)	12	3 - 17
Skin color	38	450
	No	discoloration

Dr. Jenkins looked at Greg's heart monitor and noticed that it was still 58.

"Your mother mentioned that you did not eat the morning of the game. It was hot yesterday. Did you drink a lot of fluids during the game?"

"I rarely drink during games. Doc. You get hit in the gut a lot when you run the ball, and the last thing you want to do is throw up on the field."

The doctor smiled and Mrs. Myron remembered the days when her son would forget to drink when he played outside and ended up passing out.

"Do you remember anything before you were tackled?"

"One moment I was running down the field and then I remember being in the ambulance with the P.A. announcer saying that we had won the championship."

Greg smiled and moved his arm and felt the IV in his forearm.

*Expect high glucose and salt content levels.*

"That's to counter any dehydration," explained the doctor. "How do you feel Greg? Are you nervous?" he asked Greg as he gently pinched the skin on the back of Greg's hand; it sprang back.

"Yeah, I'm feeling kind of weak and this bad headache makes me feel sort of out of it."

"Can you try sitting up?" asked the doctor.

Greg's father leaned forward to help him. Greg lifted his head. Dr. Jenkins looked at the heart monitor and noticed that Greg's heart rate increased to only 60 when Greg said that he was feeling dizzy and was seeing flashing lights.

"I'm not sure that sitting up is such a good idea," Greg murmured.



Why does Greg's new signs and symptoms **increase much when sitting up**?

What are Greg's new signs and symptoms? **weak, headachy, nauseous**

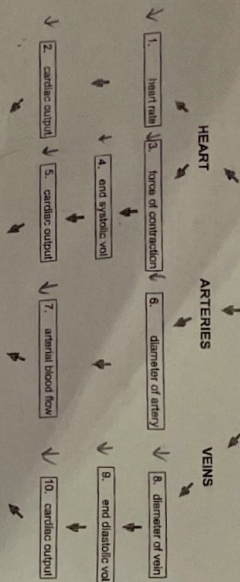
Baroreceptors are responsible for monitoring blood pressure. Where are the baroreceptors located in your body?  
a. Now you will design a pressure receptor. First, draw a circle on a piece of paper and then draw two or three lines from the center to beyond the perimeter of the circle. Imagine that the circle represents a balloon and the lines are threads, which are attached to the surface of the balloon. How would blowing into the balloon, to increase the pressure of the air inside, affect:  
a. The size of the balloon? **greater**  
b. The threads attached to the surface of the balloon? **greater tension**  
c. Imagine that the threads are the terminals and axons of sensory neurons. If the terminals are sensitive to stretch, what will happen to the frequency of the action potentials in the axons as the pressure inside the balloon is changed? **slow ↓ ↓ ↓ ↓ ↓**

What part of your model (question #3) are analogous to the carotid sinus, the sensory nerve endings, and the arterial blood? **carotid sinus: balloon sensory nerve endings: thread**

Baroreceptors send sensory information to the medulla in your brain, which then stimulates the autonomic nervous system; this is a critical part of the baroreceptor reflex. What are the two main divisions of the autonomic nervous system? **sympathetic and parasympathetic**

The chart below shows data when baroreceptors detect a drop in arterial blood pressure the sympathetic nervous system stimulates the heart and the smooth muscles in the walls of the arteries and the veins. Use an upward arrow (↑) to represent an increase or a downward arrow (↓) to represent a decrease to indicate the effect of the sympathetic nervous system on the variable in each numbered box.

### Drop in Arterial Blood Pressure SYMPATHETIC NERVOUS SYSTEM



### Increase in Arterial Blood Pressure

7. Do you have a diagnosis for Greg's problem? **he has a concussion**  
8. Describe one additional neurological test you would perform to determine what is wrong with Greg. Based on your hypothesis, predict the results you would expect from your test. **SPECT, etc. then question: if they have a concussion, they may be unable or slow at answering or MRI**

Dr. Rose came into the room to see Greg sitting up in bed watching television. **question: what or slow at answering or MRI**  
The nurse said that you got up to go to the bathroom a few times today.

Kia, I was bit dizzy at first, but I managed. I feel better now, but it would be so much easier if I didn't have to wheel her chair," said Greg, looking at the needle in his forearm.

Your blood work came back OK, Greg, but I'm afraid that IV says for a while longer."  
Dr. Rose performed a few basic neurological tests. She shone a light into Greg's eyes, ran a pen across the bottom of his foot, and gently but the tendon below his bent knee with a small rubber hammer.

Okay, there don't seem to be any problems, there. Do you still have a headache, Greg?  
**(a little better, and the flashing light have faded.)**

Those are good signs, Greg, but I think you should have an MRI to make sure that no damage was done when you were hit during the game. You know that the papers are saying that you won the game," said Dr. Rose.

She returned to her office to talk with Greg's parents. "It seems that Greg had a concussion. I think it was caused by the last tackle of the game. He experienced a blow to the head, which moved or shook his brain within his skull. This trauma did not appear to be too great so Greg only suffered a mild concussion, but I have ordered an MRI as a precaution to make sure that he does not have any permanent damage. If it comes back clean, we'll keep him under observation one more night and then discharge him around noon tomorrow; that will have given him about 48 hours with us. I'll talk with all three of you before he leaves and we can make an appointment for him to see me in my office next week. But please understand that he must rest when you take him home. He should stay inside, catch up on his sleep, and watch TV; just relax. If he exhibits any peculiar behavior, don't hesitate to call me, okay?"

### Questions

1. What part of the nervous system was Dr. Rose checking when she shone a light into Greg's eyes? **eye reflex hammer? pupil reflex**
2. What part of the nervous system was Dr. Rose checking when she hit Greg's patella tendon with a rubber foot? **stretch reflex**
3. What part of the nervous system was Dr. Rose checking when she ran her pen along the underside of Greg's foot? **stretch reflex**
4. What evidence suggests that Greg suffered from a mild concussion? **headache, dizziness, nausea, vomiting, loss of consciousness, etc.**
5. What types of symptoms would you expect if Greg's concussion had been more severe? **head, completely disoriented**
6. Do you wish to modify your diagnosis of Greg's long-term problem? **No**

Greg and his parents walked into the hospital and directly into Dr. Rose's office.  
"How have you been over the past week, Greg?"  
"I've been okay, except I felt dizzy a few times."

"I remember you as a boy playing with Jack and passing out in the sandbox. Of course, that was before I went back to school and got my medical degree," said Dr. Rose.  
"The dizzy spells seem to be getting more frequent," said Mrs. Myron. "Could it be because he has been stressed from missing school, getting into college, and getting a football scholarship?"  
"There's a knock on the office door and two nurses and an orderly entered with a table.  
"Great timing. I'm glad you feel like that Greg. There is one more test I would like you to take. Could you lie on the table facing up?"

Greg, clambered from the chair onto the table and the nurse attached sticky electrodes to measure his electrocardiogram; she attached a clip to his finger to monitor his heart beat.  
"Okay Greg," said Dr. Rose. "Move down the table so that your feet push against the plate at the bottom."

"They could all hear the keeping sound of Greg's heart in the otherwise silent room.  
"Now, we are going to tilt the table so that you come to a standing position; don't worry, the straps will prevent you from falling off the table. We'll be able to monitor your heart rate and measure your blood pressure, if necessary."

The technician tilted the table.  
"Wow," said Greg as the table began to move. The table continued to tilt and Greg's heart monitor continued to sound at about the same rate.  
"Tilt us if you feel faint," said the doctor.

"Oh boy, am I feeling dizzy," said Greg as his eyes rolled back in his head and he passed out. The table was rotated back to the horizontal position again and locked in place. The nurse placed a cold cloth on Greg's forehead and a pillow under his head as Greg came round.  
"Just lie there for a few minutes, Greg. You did great," said the doctor.

"I fainted and you said that it was great?"  
"Yes, the instruments monitored your response and this then allows me to see exactly what happened to your heart during the procedure," said Dr. Rose as she looked through the ECG recording.  
"What happened, Dr. Rose—apart from him fainting?" asked Greg's mother.

"Greg fainted as the table reached an angle of around 80 degrees. This probably would not have happened had he not felt the extra stress of being in uncomfortable surroundings here in the hospital. His heart rate did not increase sufficiently to maintain his arterial blood pressure so insufficient blood went to his brain and he passed out."

Questions  
1. Imagine a fountain where water is being shot into the air. What happens to the pressure of the water as it travels against gravity? **decreases**  
2. What is the relative position between the heart and the head (or baroreceptors in the carotid sinus) when you are standing? **heart below head**

are happens?  
4. What happens to the pressure of the blood as it travels against gravity in a standing person? **it increases**

5. The baroreceptor reflex ensures that the pressure of the blood entering the brain remains within defined limits, irrespective of body position. Under these circumstances, predict the blood pressure in the aorta of a standing person and a person who is lying flat on their back.  
6. If the baroreceptor reflex functions to maintain a constant pressure in the blood entering the brain, how does the circulatory system compensate for a person going from a lying to a standing position? Refer to the diagram in question #6 in Part III if necessary. **needs to increase blood pressure**

7. Do you wish to modify your diagnosis of Greg's problem?  
**no more sports for a while less exertion**

### Part VI – The Follow-up Visit

"I think I know what is wrong with Greg," said Dr. Rose, "although it is very difficult to be absolutely sure without genetic testing."

Dr. Rose told the family that Greg seemed to be suffering from Familial Dysautonomia, also known as FD, a genetic disease that involves a lack of maturity of the sympathetic nervous system.

"People with FD often experience the same symptoms that you are experiencing and it is common in people of Jewish descent. Often times your symptoms can be brought on by physical exertion and people with FD often experience fatigue. The reason why you fainted during the tilt table test is because your sympathetic nervous system failed to increase your heart rate and cardiac output. Normally, when standing up, the decrease in blood pressure is countered in this way. Unfortunately, since it is a genetic disease, there is currently no cure.  
"Can anything be done?" asked Greg.

"Your bradycardia, or slow heart rate, results in a low blood pressure. As I said, your sympathetic nervous system is not well developed, so when you get stressed or when you stand up too quickly you pass out."

"Is there a cure for bradycardia," asked Mr. Myron.  
"My father-in-law had a similar problem and he had a small pacemaker placed under his skin. It is silent for most of the time but stimulates the heart to beat faster when blood pressure drops," said Dr. Rose.

"There goes football," said Greg.  
"Not so fast, Greg. Let's not go off the deep end. I believe that you have a mild form of FD and I know that there are medical treatments. I would like you to see a cardiologist. We have a good one on staff here at the hospital, so let's see what he has to say."

Greg's parents looked at one another.  
"It's important that you are healthy, Greg," said Mrs. Myron. "You've had a tendency to faint ever since you started walking, so let's look into fixing this problem once and for all."

"Quite right," said Dr. Rose. "I'm sure I'll be seeing you for more tests in the near future."

### Questions

1. What tests do you think the cardiologist will order? **MRI, felt to see how he performs standing quickly**
2. If a pacemaker is implanted to control Greg's heart rate, what life changes will be forced upon him?
3. Do you think Greg will ever play competitive sports again? **No**

no more sports for a while less exertion