

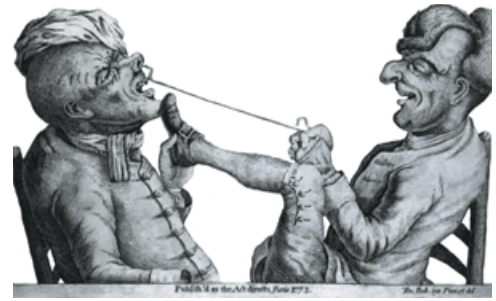
# Taking It on the Chin: A Case Study on the Nervous System

by

**Stephanie DeMarco, Caitlyn Woods, and Phil Stephens**

Biology Department

Villanova University



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## Part I—The Dentist

John Gower, a retired 76-year-old man, gets up early and goes directly to his dentist for a root canal. He doesn't even notice the beautiful spring day with mild temperatures, a stiff warm breeze, or even the characteristic smell of newly laid mulch around the dentist's office. Nancy Gower sits in the waiting room as her husband walks directly into the surgery. The nurse sets him up for the anesthetic, and he mentions that the room seems hot and stuffy.

The nurse smiles and asks, "Would you like me to open the window? The landscaping crew is putting mulch on the gardens and the smell is very strong."

"That's fine. I'd rather have the breeze."

The nurse pulls the window open and quickly closes it again because the wind blows the curtains and brings some mulch into the surgery.

"Maybe I'll just leave it cracked open," she says. Mr. Gower nods and the nurse picks up pieces of mulch from the carpet and the chair before the dentist comes in.

Dr. Pincher comes in to administer the Novocain and begins the procedure on Mr. Gower's molar.

A little while later the root canal is done. Dr. Pincher tells his patient that the procedure went well and that the anesthetic should wear off soon. He explains to the older couple that Mr. Gower's mouth will feel tender and may be sensitive to hot and cold substances. He should take it easy for the next few days and take ibuprofen, as needed. The dentist assures them that Mr. Gower's recovery should be fine, and that if he has any questions or suffers from any side effects, he should call the office. Mr. and Mrs. Gower leave and go straight home.

Later that day and into the evening, Mr. Gower feels light headed, but thinks that it might be the last traces of the Novocain. He tells his wife that he will probably be fine in the morning.

### Questions

1. List the symptoms experienced by Mr. Gower.
2. Novocain blocks action potential production at the site of injection. How do you think Novocain works on the axon membrane, and how does it block the sensation of pain?



## Part II—Day 2

“Mrs. Gower wakes up. She lets her husband continue sleeping. She smiles as she closes the bedroom door because he is usually up early, but she understands that yesterday’s root canal must not have been easy for him. About an hour later, she checks on her husband and finds that he is awake but he has had a very rough night.

“My jaw is really stiff, Nancy, and it hurts more than the last time I had a root canal.”

Mrs. Gower brings him some ibuprofen and tells him to stay in bed until it gets into his system. When she returns, Mr. Gower tells her that his jaw is still stiff and that every time he tries to get up, he feels faint and has no energy or strength. This makes Mrs. Gower very concerned.

“I’ll get the blood pressure machine, John.”

Mr. Gower smiles. They bought the machine when Nancy was diagnosed with high blood pressure, and now, every time he felt sick, she took his blood pressure with it.

“It’s 100 over 60, John, and it’s usually 120 over 70.”

Mrs. Gower calls the dentist’s office, and they tell her that his problems are probably due to the procedure. They suggest that Mr. Gower stay in bed and drink plenty of fluids, and that she should call again if he gets worse.

Mr. Gower eats nothing during the day, and just drinks fruit juice. At dinner time, his jaw is so stiff he has trouble opening his mouth to eat the soup and rice pudding his wife has made for him. Mr. Gower goes to sleep early that evening with the hope that he will be better after a good night’s sleep.

### **Questions**

1. What new symptoms does Mr. Gower exhibit?
2. Which of these symptoms could be due to the previous day’s procedure?
3. Why can’t Mr. Gower open his mouth?
4. What are the possible diagnoses for Mr. Gower’s condition at this time? For each diagnosis that you come up with, describe the symptoms that relate to that diagnosis.



## Part III—Day 3

After another restless night, Mr. Gower wakes up sweating. The window is open, he is completely uncovered, yet he feels hot. His jaw is still shut, his neck seems rigid, his mouth is very dry, and he feels like his lips are stuck to his teeth in a foolish grin.

“Are you all right, John?”

“I feel awful, Nance.”

“I’ll take your blood pressure.”

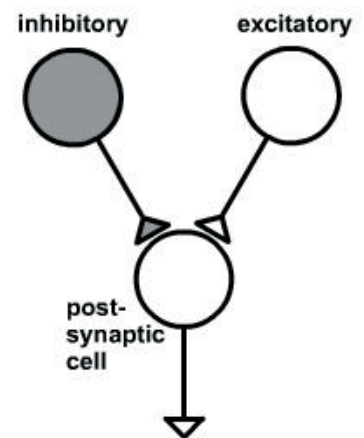
“Not now. I think it’s time to go to the Emergency Room.”

Nancy walks into the bedroom and turns on the light. Her husband’s face is drawn back, in a contorted grimace. She draws back at first, then walks over and puts her hand on his forehead.

“Oh John, you look terrible and you’re burning up.”

### Questions

1. What new symptoms does Mr. Gower exhibit?
2. Is there a common factor between his jaw being locked shut, his rigid neck, and his lips being drawn across his mouth in a constant grin?
3. Look at the diagram of three nerve cells on the right. At the bottom, there is a postsynaptic cell, which receives chemical synapses from two presynaptic cells, which are shown at the top of the diagram. One of the presynaptic cells is labeled excitatory and the other is labeled inhibitory. Assume that a single action potential in a presynaptic cell does not produce an action potential in the postsynaptic cell. Show (by drawing a graph of membrane potential against time) how the membrane potential of the postsynaptic cell changes if there is one action potential in:
  - a. only the excitatory presynaptic cell.
  - b. only the inhibitory presynaptic cell.
  - c. both the inhibitory and the excitatory presynaptic cells.
4. Now think about how the two presynaptic cells could produce an action potential in the postsynaptic cell.
  - a. Which presynaptic cell must have action potentials to produce one or more action potentials in the postsynaptic cell?
  - b. What phenomena must take place for the small postsynaptic potentials to reach threshold and produce action potentials?
  - c. If the frequency of action potentials in this presynaptic cell (#4a) increases, what happens to the number of action potentials in the postsynaptic cell?
  - d. What happens to the number of action potentials in the postsynaptic cell if the other presynaptic cell (#4a) also produces action potentials?
5. Assume that the postsynaptic cell in the diagram is a motor neuron. If Mr. Gower’s problems are associated with maintained muscle contraction, what must take place in the motor neuron to produce a maintained muscle contraction?



6. Assume that both presynaptic neurons have action potentials. What two conditions in these presynaptic cells would produce an increase in the number of action potentials in the postsynaptic (motor) neuron?
7. Do you wish to change or modify your diagnosis of Mr. Gower's problem?



## Part IV—The Emergency Room

Dr. Umphasea, an African doctor on a six-month rotation in the U.S., is attending at the Emergency Room. He notices that Mr. Gower's jaw is firmly closed and his neck and lip muscles are contracted.

"I have seen cases like this before in my home country. I have a simple test to confirm my diagnosis. Mrs. Gower, has your husband eaten recently?"

Mrs. Gower shakes her head, "No."

The doctor places a wooden tongue depressor through Mr. Gower's clenched teeth and onto the back of his throat. Mr. Gower reacts, but does not open his mouth to regurgitate.

"When did you last have a tetanus shot?"

His wife interjects, "He hates needles, doctors, and dentists."

The doctor smiles, "I don't blame you. We need to take some blood to do an antibody titer. We'll also culture the wound in your mouth, but I don't know whether we'll find anything there. Your chart says that you have no allergies. Is that correct?"

Mr. Gower nods his head yes.

The doctor continues, "Because I'll probably give you penicillin."

### Questions

1. What is the normal response to someone placing a tongue depressor on the back of your throat?
2. Why didn't Mr. Gower open his mouth with the tongue depressor test?
3. What does this tell you about the action potential activity in Mr. Gower's motor neurons to his jaw (and neck) muscles?
4. Go back to your answer to Question 6 in the last part of the case. Do the results of the tongue depressor test support one of the two answers?
5. What does the antibody titer tell the physician?
6. Does this explain his fever?
7. Why is penicillin prescribed for Mr. Gower's condition?
8. How did Mr. Gower initially become infected?
9. Do you wish to change or modify your diagnosis of Mr. Gower's problem?



## Part V—The End of the Day

About an hour later, Dr. Umphrease enters Mr. Gower's cubicle in the ER holding a folder. Mr. Gower is asleep, so the doctor talks to his wife.

“The lab results are in and they confirm my initial suspicion from the tongue depressor test. Your husband is infected with *Clostridium tetani*, a bacterium that usually lives in the soil. The wound culture came back negative, but I am pretty sure that it entered his body through the incision made by the dentist while doing the root canal.”

The doctor continues, “The penicillin should clear up the bacteria. The nurse has cleaned up the wound and given him shots of antitoxin and a tetanus vaccine. We are going to keep him here for a few days before we release him. I will prescribe diazepam, which is a tranquilizer that will help relax the muscles. Do you have any children at home?”

Mrs. Gower answered, “Our grandchildren are supposed to come visit next month, over Easter, but we can cancel if necessary.”

“Well, let's not do that right now. When he gets home, he will need an environment with dim lights, little noise, a constant temperature, and lots of bed rest. He will continue with diazepam, but you will have to be careful to follow the directions, because it is a highly addictive drug. We'll probably give you some sedatives if he has trouble sleeping while he is here, but judging by his appearance right now, he probably won't have any problems with sleeping.”

Mrs. Gower smiles.

The doctor continues, “The treatment may take a long time. I think we caught the infection early, but you will need to keep an eye open for signs of breathing difficulties and pneumonia.”

### Questions

An action potential in a motor neuron produces a contraction of the muscle fibers it supplies. Tetanus toxin is thought to decrease inhibitory synaptic effectiveness, especially onto the motor neurons to the face and neck. As a result, the motor neurons produce more action potentials than usual and the muscles remain contracted over a long time period. One effect of tetanus infection is called *lockjaw*.

1. Fill in the flow diagram (see next page) for inhibitory chemical transmission.
2. Look at each stage in the diagram and suggest how tetanus toxin could decrease the postsynaptic response, i.e., the response of the motor neuron.
3. Think about the release of synaptic transmitter and its reaction with the postsynaptic receptor to open a channel. How could benzodiazepines, like diazepam, work to counteract the effect of tetanus toxin?
4. What characteristic does Mr. Gower possess that would make him be more susceptible to the tetanus toxin?

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