

[Viagra®](#) is one of the most popular drugs of all time:

- Google mentions over 17 million web sites that use the word "Viagra." In comparison, Google lists only 3.3 million web pages using the word "aspirin" and only 936,000 sites containing the word "Tylenol."
- Every day, billions of spam e-mails advertise Viagra®. In fact, there is so much Viagra spam, that the drug's producer, Pfizer, has created a special web page related to the problem, named Avoid Fake Viagra: The Facts About Spam, substantially listed on [Viagra.com](#).
- Pfizer has allocated millions of dollars to advertise Viagra®, so people can see commercials for the drug permanently on TV.
- Pfizer states on its web site that nine Viagra® tablets are provided every second. It gives close to 300 million pills every single year.

The recognition of Viagra® brand is so good that almost every adult in America knows, or at least has heard of the drug and can tell you how it works.

How does it work? It's simple — when it works as intended, Viagra® causes that a man who is sexually stimulated gets an erection.

How does Viagra® cause that? And why does Viagra® act only in case when the man is sexually stimulated? For that matter, what triggers an erection in the first place? This article is to help you find answers to all of these questions and more...

## How does the penis work?

Lots of people find it difficult to talk about the penis. This part of the male anatomy is considered private and usually we do not discuss it in public. However, the penis is just a part of the body created to do a task, and we will treat it that way.

There are actually two tasks that the penis has to handle:

1. to release urine from the bladder (**urination**)
2. to release sperm and seminal liquid from the prostate gland (**ejaculation**)

Viagra® makes the second task easier — it helps with ejaculation.

When things work as they should, ejaculation proceeds in three stages:

- Stage no. 1: The man gets sexually aroused.
- Stage no. 2: The penis becomes erect.
- Stage no. 3: Stimulation of the penis results in ejaculation.

That seems to be quite simple, but the truth is that in many cases, stage no.2 just does not happen, making the last stage difficult or even impossible. Despite the fact that the man is sexually stimulated, the penis does not get erect. To understand why it happens, you have to find out some details on the technology of erection.

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## The Technology of Erection

If you want to change position of any part of your body, you can achieve it by using muscles. Whether you are moving your legs, arms, toes or fingers — your muscles are involved. Even when you want to stick your tongue out, you must engage your muscles.

- You decide to move a part of your body.
- The appropriate muscles respond.
- The appropriate part of the body moves.

Thanks to the muscles people are able to move their bodies voluntarily with exact control.

On the other hand, the penis appears to be completely different. There are **no muscle contractions** that make the penis erect. To get erect, the penis needs **pressure**.

The easiest way to grasp how the penis becomes erect is to imagine a balloon. A balloon is limp if it is not filled with air. As you fill such a balloon with just a little air, it becomes rigid and elongated.

The similar mechanism occurs in the penis — to become rigid the organ needs **pressurized blood** instead of pressurized air. There are two cigar-shaped structures in the penis — so called **corpora cavernosa** (*singular - corpus cavernosum*), that are used to make the penis erect.

Imagine that the corpora cavernosa are balloon-like tubes. **Arteries** supply blood into these tubes, and **veins** take blood away from them. The penis can be either floppy or rigid, it depends on the flow of blood:

- When the penis is not erect, the arteries that supply blood into the corpora cavernosa are slightly constricted, while the veins that take the blood away are open. The pressure cannot be built inside the organ, so the penis is limp.
- When a man gets sexually aroused, the arteries leading into the organ open up so that pressurized blood can get in the penis rapidly. The veins leaving the organ constrict. The blood is trapped in the corpora cavernosa, and it results in the elongation and stiffness. The penis gets erect.

**If the arteries leading to the organ do not open up as they should, it is hard or even impossible for a man to get erect.** This problem is the main cause of erectile dysfunction.

To deal with an erection problem when the reason lays in poor blood flow, you have to open up the arteries. Let's think about how this can be achieved — and how it was achieved before era of Viagra.

## Curing Erectile Dysfunction

The first meaningful breakthrough in the curing of erectile dysfunction took place in 1983. Prior to that time, it was claimed that erectile dysfunction, the state of being unable to get an

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erection, was mainly **mental**. That concept collapsed in 1983 in Las Vegas, at the American Urological Association meeting when **Dr. Giles Brindley** injected his penis with the **phentolamine**. Afterwards, Dr. Brindley stood on stage and dropped his pants to show one of the first drug-caused erections to the skeptical group of urologists.

What did the drug phentolamine cause? It managed to relax a muscle. Here's how it happened:

Inside the human body there are various kinds of muscle:

- Skeletal muscles are these muscles that we admire at the Olympics — e.g. biceps
- Cardiac muscle — their job is to power the heart
- Smooth muscle are placed in blood vessels, the stomach, the intestines and so on. They usually **act involuntarily**.

Smooth muscle are the most crucial elements in every erection. Drug phentolamine is able to **relax smooth muscle**.

The reason why phentolamine resulted in Brindley's erection was particularly interesting in 1983 because prior to that time nobody had really thought about it. What happened?

- The constricted arteries of a limp penis do not let the blood enter the corpora cavernosa.
- Injection relaxed Brindley's smooth muscle in the artery walls of his penis and it made them to open up.
- Blood flew into the corpora cavernosa, and the blood pressure acted on his penis, giving him a prompt erection.

In the mid 1980s, it became popular for men suffering from erectile dysfunction to use drugs that relax smooth muscles as a cure for the problem.

Viagra® makes the things easier because it causes the same effect with a tablet instead of an injection. The next advantage of Viagra® is the fact that the drug results in an erection only when the man is aroused, contrary to the phentolamine that causes a sudden and uncontrolled erection.

How can a tablet influence only the smooth muscle in the penis and not in the whole body? How is it possible that it acts only when the man is aroused? To answer these questions, we have to understand the process of blood flow in the body.

## Opening Up

How can a pill give an erection to a men? If a man took a pill containing a general smooth-muscle relaxer, like phentolamine, it would result in relaxation of all the smooth muscles in his body. That might cause lots of problems. What men really need is a medicine that acts only on the muscles in the arteries of the penis.

To understand how to create a drug that is to act only on penis, consider the way blood flows in human body. There is only one pump in human body — the heart. But various parts of the

body require different amounts of blood and — to make things more complicated — at different times.

For instance:

- If you consume a proper meal, your body requires to get more blood to the stomach and intestines in order to make digestion possible.
- If you are a participant of a marathon, your body requires to get more blood to muscles of your arms and legs. It may want to limit most of the blood flowing to your stomach (and other organs) to save oxygen for your legs.

In other words, what your body requires, is a set of **valves** that can be used to decrease and increase blood flow to particular parts of your body. And your brain requires a mode to supervise those valves so it can turn them on or off when it is needed.

**The penis is one of the organs in the human body where the brain requires to be able to turn on and off the blood flow with a valve.** To grasp how human brain supervises this particular valve, let's start with the elementary issue: How does the brain control the flow of blood to different areas of the body?

### Turning Valves On and Off

In a body of a human, the "valves" open and close with the help of muscles in the walls of arteries. When these muscles are relaxed, the arteries open up and flow of blood increases. The valves react on chemical messages that are controlled by the brain.

The mechanism of "opening a valve" in any part of the body consists of four steps:

1. The brain sends a signal to a particular **nerve fiber**. This nerve fiber finishes in an **NANC nerve cell** in an artery, somewhere close to the point where blood flow is to change. NANC is an abbreviation for nonadrenergic-noncholinergic and it means that the NANC nerve cell can create **nitric oxide**.
2. The NANC nerve endings supply **nitric oxide** into the blood and nearby cells.
3. The nitric oxide acts on an enzyme called **guanylate cyclase** in surrounding cells, and this enzyme begins to produce a chemical — **cyclic guanosine monophosphate (cGMP)**.
4. cGMP acts on **smooth muscles** in artery to **relax**. When they do, the flow of blood increases.

This mechanism reminds a simple small chemical machine, and it is used by the brain to increase the flow of blood in a few different areas of the body. But there is one last part to this machine: Another enzyme, known as **phosphodiesterase (PDE)**, deactivates the chemical cGMP.

cGMP is generated as long as the brain sends messages to the nerve fibers in the artery, which supply nitric oxide and keep the cycle going. If the brain stops sending the signal, all of the cGMP disappear because PDE deactivates it. This way, the brain is able to turn valves on and, in the same way, turn them off.

So how is it connected with erection?

### Supervising the Penile Valve

You can now understand how an erection happens. When the brain becomes aroused, the penis receives a signal. Nerve cells in the corpora cavernosa begin to produce nitric oxide, which cause the creation of cGMP. The cGMP makes that arteries in the corpora cavernosa dilate and it causes the increased flow of blood into the penis. The extra amount of blood flowing into the penis inflates it, like a balloon. An then an erection occurs.

When a man has a problem of erectile dysfunction, it can be caused by many reasons. Though, one of the most prevalent reasons, particularly in older men, is the fact that the arteries in the organ are not dilating sufficiently when the signal is sent by the brain. The man is aroused, the nerves are generating NO; but the final amount of cGMP is not enough to keep an erection.

The way that Viagra® works to solving this problem is quite amazing and brings the following question: How is it possible to create a medicine that acts only on the penile valve?

### The Viagra® Method

If you want to create a medicine that increases a flow of blood to the penis, you have at least three methods to do it:

1. Boost the amount of nitric oxide generated in the penis
2. Boost the amount of cGMP generated in the penis in reply to the nitric oxide
3. Exclude the PDE in the penis in order to the cGMP builds up instead of being decomposed by the PDE

Viagra® uses the third method — the drug eliminates the PDE that causes a decomposition of the cGMP, so cGMP builds up in the organ and has more significant effect on the artery walls. The greater the quantity of cGMP — the larger the blood flow, and the larger the blood flow — the larger the degree of the erection.

The reason that Viagra® uses this method results from an amazing quirk of PDE.

It turns out that the body of a human being has at least **11 different sorts of PDE** that it generates. Only one of those sorts of PDE — **PDE5** — is found mainly in the penis. Once experts discovered this fact, the invention of Viagra® was comparatively simple. All that Pfizer had to find was a chemical that would be able to **selectively block PDE5**. When the PDE5 is blocked, cGMP can build up in the organ and boost the blood flow there without acting on other areas of the body.

If the unique type of PDE were not found in the penis, today we would not have drug called Viagra®.

So how does Viagra® block PDE5?

## Targeting PDE5

PDE5 is an **enzyme**. An enzyme is a special kind of protein that accelerates a chemical reaction. For instance, the article [How Cells Work](#) tells about the maltase enzyme. Maltase is formed in such a way that a maltose molecule can suit right in, and when it does, the maltase enzyme divides the maltose molecule in two glucose molecules, **as shown here**:

PDE5 **accepts cGMP and breaks it down**. Pfizer required a chemical that would prevent PDE5 from doing its job. The chemical discovered by Pfizer is known as **sildenafil citrate**. It suits right into the PDE5 enzyme and stops it from working.

Viagra® contains sildenafil citrate in form of a tablet. When a man receive a Viagra® tablet, the sildenafil citrate runs through his body, but it really acts only on the PDE5 enzyme in the penis. The drug remains in the bloodstream for approximately four hours, and then the liver and kidneys get rid of it from blood.

And this is the end of the "how it works" part of the Viagra® story:

- A man receives a Viagra® pill
- The sildenafil citrate gets to his bloodstream and runs through his body.
- The sildenafil citrate joins to the PDE5 enzyme in his penis and damages most of it.
- When the man gets sexually aroused, the normal message is sent by the brain to the NANC cells in man's penis, which generate nitric oxide as normally.
- The nitric oxide generates cGMP, which begins to relax the arteries in the penis.
- Since the PDE5 has been damaged, the cGMP builds up instead of breaking down and makes the arteries in the penis entirely dilate.
- The penis gets filled with blood and the man receives a full erection.

This works superbly for the most of men, except for a few smaller problems...

### Side effects of the drug

Very few medicine work perfectly, and this concerns Viagra as well. Every drug causes **side effects** that appear because the drug is running through the body and may unintentionally act on various parts of the body. For instance, aspirin is a medicine that brings pain relief, but it can also bring side effects — damage the stomach lining and dilute the blood.

Viagra® has a few side effects and patients have to be aware of them.

The first problem is connected with the fact that Viagra® tends to have a spill over effect. The drug blocks PDE5, but it also acts on **PDE6**. Enzyme PDE6 is used by the cone cells in the retina, so Viagra® can act on **color vision**. Lots of men who take Viagra® note a change in the way they perceive blue and green colors, or they see everything with a bluish shadow for several hours. And this is why pilots cannot take Viagra® within 12 hours of a flight.

The second problem appears when people take drugs like **nitroglycerin** to treat angina. Nitroglycerin increases nitric oxide and it helps **angina sufferers** by opening up the arteries that supply oxygen to the heart. If a patient takes nitroglycerin and Viagra® at the same time, the increased nitric oxide with the blocking of PDE5 can cause some problems.

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Other problems related to using Viagra® may be minor, like **headaches** (the drug, as a side effect in some patients, opens up arteries of the brain's lining and results in excess pressure) or major, like heart attacks. The risk of heart attacks is a reason why Viagra® is a prescription medicine rather than an easily accessible drug like aspirin. A doctor needs to know your medical history and has to be sure that this drug will not result in a heart attack. Occasionally, patients taking Viagra® suffer from **painful and long-lasting erections**. They have to see a doctor to find solution to the problem.

At last, there is a concern that some men, particularly younger ones who receive Viagra® despite the fact they do not really need it for physical reasons, may become addicted to Viagra®. It means that they may become unable to keep an erection without Viagra®.

For further information about side effects, see [RxList: Viagra® Side Effects](#).

### **What about Levitra® and Cialis®?**

Viagra® is an extremely successful medicine, and other drug companies wanted to benefit from this success. They created different chemicals to block the PDE5 enzyme and two new drugs: **Levitra®** (vardenafil) and **Cialis®** (tadalafil) appeared on the market.

Because Levitra® and Cialis® block the PDE5 enzyme, they work exactly in the same way as Pfizer's drug. They help men who have problems with maintaining an erection because of problems with blood flow and they act only when men are sexually aroused.

Levitra® and Cialis® block PDE5 with different chemicals and there are some meaningful differences between these drugs. For instance:

- Only Viagra® may result in color-vision problems.
- Cialis® results in muscle aches in about 5 percent of users.
- Viagra® and Levitra® remain approximately four hours in the bloodstream. Cialis® remains in the bloodstream much longer (it shows a 17.5-hour half life) and therefore it can stay effective for more than a day.

To get further information about Viagra and other drugs that cure erectile dysfunction, as well as related topics, check out the links on the next page.

For more information visit:

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