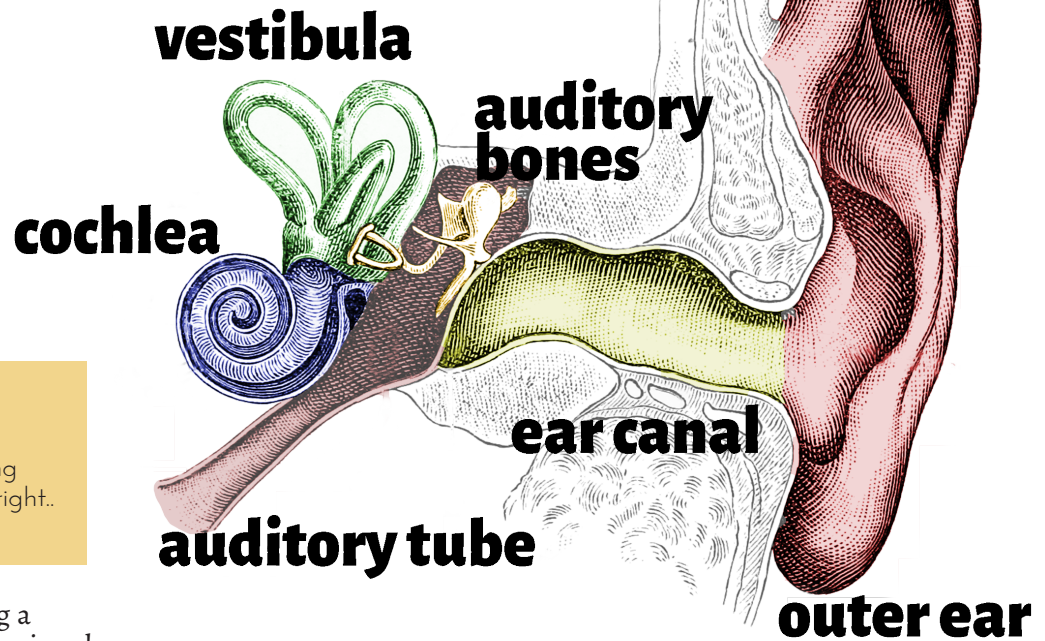


# HEARING LOSS

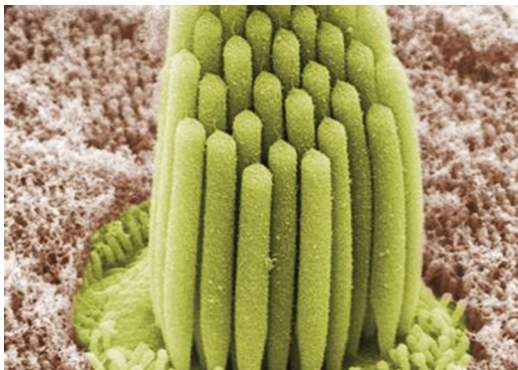


## Fun Fact!

Drummers tend to lose hearing in the left ear more than the right..

Being a professional musician **quadruples** your risk to suffer noise-induced hearing loss and increases the risk for tinnitus by more than half. Drummers have more hearing loss than any other instrumentalist. A 2006 study at the Percussive Arts Society found that 57.6% of professional drummers and 44.2% of amateurs have tinnitus - ringing in the ears. Just 14-17% of non-musicians have tinnitus.

This sounds like a lot - but the problem is even worse. Playing music actually improves your hearing, so the true amount of hearing loss is even higher. It is a big problem. Here's what you need to know about the mechanics of sound and the ear to understand both how hearing loss works and what to do about it.



*This photograph is of Inner ear hair cell in a frog.*

# How The Ear Works

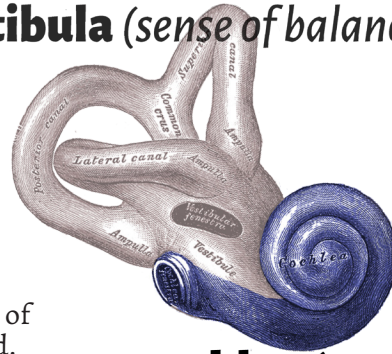
The ear is essentially a specialized form of touch. It feels the air outside and responds to a special kind of changes in air pressure - sound waves.

Most of the ear works like a drum. In this metaphor, the thing actually making the sound (raindrops hitting the roof, for example) is the batter head. When the sound waves reach the ear itself, the outer ear and the auditory canal resonate and amplify the sound waves - like the shell of the drum. The ear drum works like the resonant head.

The ear drum moves 3 tiny auditory bones that work like a preamp; further amplifying the sound and transmitting it into the cochlea. The **cochlea** is a coiled tube filled with fluid and a strip of sensory cells running in a line from end to end. The strip is called the **Organ of Corti** and it houses the sensory cells, a.k.a. the ear hair cells, and their support cells. The auditory nerve connects the Organ of Corti directly to the brain.

As the sound waves travel through the cochlea, they knock over hairs, flipping a switch and turning sound from a mechanical signal - the moving fluid - into an electrical signal that travels to the auditory cortex of the brain. The signal from each part of the cochlea has a particular part of the brain that matches it. From there, the signals are sliced apart, analyzed and put back together, and finally combined with vision and other sensory information into the final picture of what we perceive as sound.

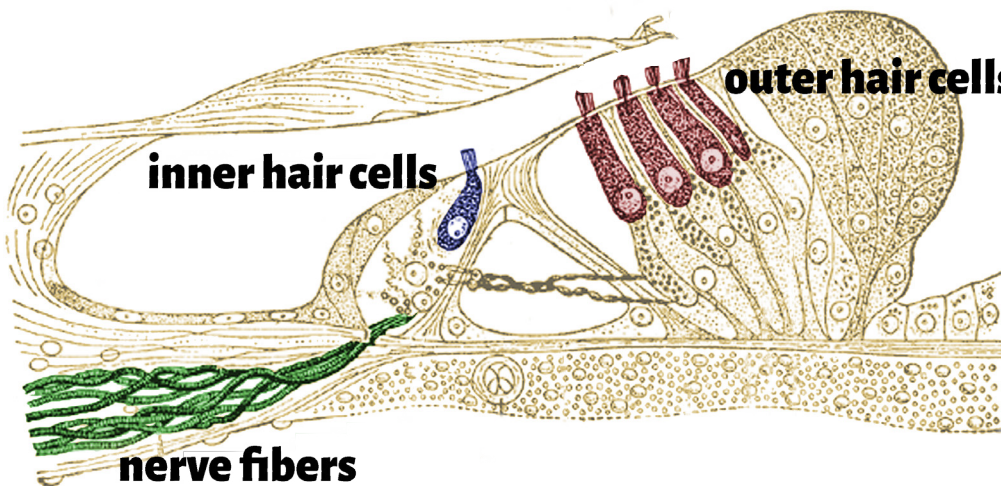
**vestibula (sense of balance)**



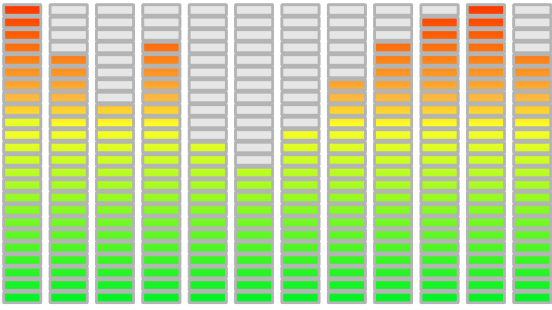
**cochlea (sense of hearing)**

## Fun Fact!

The world's record for single strokes in 1 minute is approximately 20 Hz. If we get any faster, the pitch will begin humming with a pitch. Another fun fact: The lowest note on a grand piano is 32.7 Hz.



The Organ of Corti is where the ear's sensory cells are.



This strip of sensory cells works a lot like a graphic equalizer. Each section of the cochlea is finely tuned to respond only to a very narrow band of frequencies and ignore the others. The thick end responds to lowest pitches while the tiny end in the middle of the coil responds to the pitches.

*Sensory cells in the Organ of Corti are lined up like a graphic equalizer. The farther away from the ear drum the hair cells are, the higher the pitch is that they respond to.*

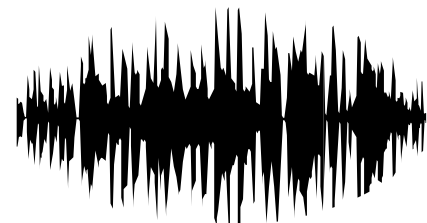
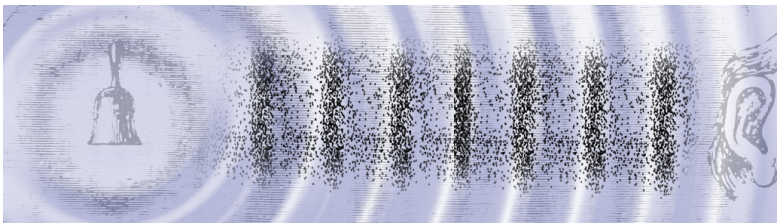
The faster those waves are moving up and down, the higher the pitch. Pitch is measured in **Hertz (Hz)**, the number of times per second something happens. For instance, if you spin around in circles fast enough to get dizzy, you are probably spinning at 2-4 Hz. Humans will hear a pitch in any sound that is vibrating between 20 Hz and 20,000 Hz. The ear is tuned to hear the human voice - so pitches between 500 Hz and 2,000 Hz are louder to our ears than they really are.

If you think of sound waves as ocean waves, then volume is how high the wave is. The difference between water waves and air waves is that water doesn't compress. When pushed, water stacks up - making water waves literally higher. Air compresses, so when pushed air makes pressure waves. Big sound waves move a lot of air, and that creates bigger changes in air pressure. The higher the pressure, the higher the volume (a.k.a. **SPL** or Sound Pressure Level.) If you ever hear a sound tech talk about speakers that "move a lot of air," he's really just saying that they are loud. The main reason that bass tones shake your chest is that they need a lot more volume to be heard. Bass tones are outside of the range of the human voice, and so the ear isn't very good at hearing them. This means that in order for them to seem like they are the same volume to us, they need a lot more air to move. This extra power is often enough to shake our bodies.

## Fun Fact!

The reason there is a +/- 3 dB switch on many amps and mixers is because adding 3 dB approximately doubles the energy (but not the perceived volume).

The SPL is measured in **decibels (dB)**. The perceived volume of a sound doubles for every 10 dB, but the actual energy of the wave increases by a factor of 10 for the same change. A dishwasher in the next room is half the volume of a normal conversation, but the energy of the sound wave is only 1/10th. A nightclub or orchestra pit is 32 times as loud, and the waves are 100,000 times larger or more!



*Sound waves are pressure waves. The object creating the sound vibrates, pushing the air away from it with each vibration. The waveform at the right measures SPL. The higher the spike is, the higher the pressure.*



# Noise Induced Hearing Loss

Drummers have more hearing damage than any other musician. This damage isn't random. It is because our instrument is the loudest of all the acoustic instruments and unlike the amplified instruments; it isn't easy to just turn it down. Luckily, noise induced hearing loss - the technical term for what we suffer from - is largely preventable if you know what to do.

## Bang!

Noise induced hearing loss can come from a single very loud event or from the slow accumulation of wear and tear on the ears. Damage from a single loud sound is kind of like breaking a bone. The structures inside the ear physically rupture causing permanent damage. Consider that a symphonic orchestra peaks at 120 decibels to 137 decibels and a full-throttle rock concert tops 150 decibels, and you can see the problem.

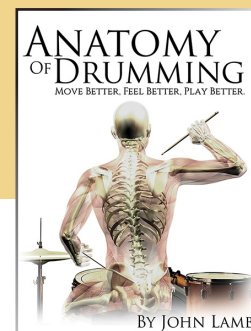
## Fun Fact!

A single snare strike can reach up to 137 dB

## The Decibel Scale

Threshold of Hearing	<b>0 dB</b>	Can't hear anything
Broadcast Studio Interior	<b>10 dB</b>	1/32nd as loud as conversation
Quiet House Interior	<b>20 dB</b>	1/16th as loud
Watch Ticking	<b>30 dB</b>	1/8th as loud
Humming Refridgerator	<b>40 dB</b>	1/4th as loud
Dishwasher in the Next Room	<b>50 dB</b>	1/2 as loud
Normal Conversation	<b>60 dB</b>	
Vacuum Cleaner at 3m	<b>70 dB</b>	Twice as loud
Passing Car at 3m	<b>80 dB</b>	4 times as loud
Average Volume of High School Band Room	<b>90 dB</b>	8 times as loud
Gas Lawn Mower at 1m	<b>100 dB</b>	16 times as loud
Night Club with Live Band	<b>110 dB</b>	32 times as loud
Sirens, Threshold of Pain	<b>120 dB</b>	64 times as loud

Excerpted from *Anatomy of Drumming: Move Better, Feel Better, Play Better*



Because louder sounds have more energy, they are more likely to damage the ear. This much is obvious. What isn't obvious is that the energy in a sound increases a lot faster than it seems to. As the dB level of a sound rises by 10, we think the volume doubles (2x), but the actual power in the sound increases by 10x. If the volume increases by 20 dB, we think the volume quadrupled, but the actual energy raised by 100x.

## Fun Fact!

Don't be offended - I'm not trying to make a subtle drummer joke. "Noise induced hearing loss" is a technical term. Noise is a general scientific term for sound, so any noise - music included - counts.

## Accumulated Damage

Damage from wear and tear is more like the rapid aging of the ear. When you hear too-loud sounds for too long, the repair processes of the ear can't keep up with the rate of damage. This kind of damage is calculated as an average volume over time. There is a lot of variation from person-to-person, but in general hearing loss starts with long or repeated exposures to sounds at or above 85 decibels.

The slow accumulation of damage is not noticed until it becomes significant. The first sign is usually difficulty distinguishing between voices in a group conversation or on the phone.

Once it sneaks up on you, there isn't much you can do about it. Remember, the actual energy level has to go up by 10x for the sound to seem like it doubles to us.  
Warning Signs

The good news is that there is a lot you can do to prevent it. **The first thing to know is what the warning signs are:**

- Your ears hurt from the noise.
- Your ears feel "full" or "stuffed".
- You find that you have to raise your voice to speak to someone standing next to you.
- Your ears start buzzing or ringing, even temporarily.
- You don't hear as well anymore.
- Your ears get "tired", and you don't want to listen to any sounds anymore.
- If you find any of these to be true, it will be worth your time to do something about it. Your ears will thank you.

A story from my dad: "I remember hearing Commander Cody and the Lost Planet Airmen back in the late 1960's at the Armadillo World Headquarters in Austin. I was there to drink beer and observe, as a fellow musician, how they did sound check. I clearly remember them telling the sound tech to put 90 dB in the mains and 120 dB in the monitors. An invitation to catastrophic old age hearing loss."



*Listening to headphones at loud volumes for long periods of time doesn't give your ears the time they need to rest and repair the damage that has been done to them.  
photo credit: Toby Bateson*

## To avoid damage:

**Reduce Volume at the Source:** Turn down the volume knob a notch. Use practice pads. Fix that noisy muffler. Put up some baffles to absorb some of the sound so there isn't as much noise in the air. It isn't always possible, but when it is, it is the easiest way to reduce noise induced hearing damage.

**Move away.** The power of sound decreases exponentially with distance. If you double the distance from a sound source, you reduce the volume by 6 dB. It doesn't sound like much, but extra distance reduces the energy to  $\frac{1}{4}$  of what it was. This is important to understand when you are deciding where to set up your drums on stage, and also when fixing something on the fly. Ever try to adjust your snare stand or bass drum pedal while playing? Leaning over places your head near the snare, exponentially increasing the volume and the risk. It is safer just to skip the backbeat until you get the adjustment made.

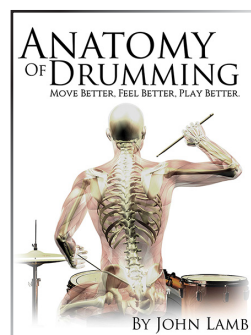
**Limit exposure.** Reducing the total exposure at one time makes a big difference. Give yourself a break from the sound when you can. Shorter rehearsals, walking outside on the set breaks, anything to keep that noise damage from accumulating.

**Ear plugs.** Ear plugs are one of the simplest and most effective ways to prevent noise induced hearing loss. See ear plug guide on page 164.

## Fun Fact!

Some people are more resistant to hearing loss than others. It is unknown why, but resistance seems to have a strong genetic component. However, like aging, there is no escaping it eventually. Even if you are one of the lucky few, it will still be worth your time to protect your hearing so that you can hear better, longer.

Excerpted from *Anatomy of Drumming: Move Better, Feel Better, Play Better*

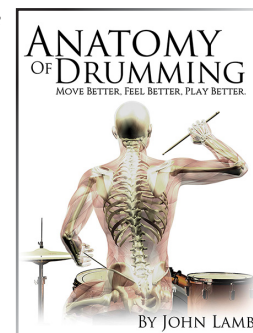


## Hearing Loss in T- ...

Sound Level	NIOSH Standards (1998)	OSHA Standards (2009)
85 db	8 hours	16 hours
88 db	4 hours	10.6 hours
91 db	2 hours	7 hours
94 db	1 hour	4.6 hours
97 db	30 minutes	3 hours
100 db	15 minutes	2 hours
110 db	2 minutes	30 minutes
115 db	28 seconds	15 minutes

*These are the guidelines for allowable for on-the-job volume and duration from the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH), a branch of the Center for Disease Control and Prevention (CDC). Anything more than this is considered to be dangerous by these organizations. The durations listed are not “at one sitting” maximus - they are daily maximums. You’ll notice that the OSHA standards are much longer than the NIOSH standards. OSHA standards go by the assumption that the energy level of the sound doubles every 5 dB. It doesn’t. It doubles every 3 dB - which is reflected in the NIOSH standards.*

Excerpted from *Anatomy of Drumming: Move Better, Feel Better, Play Better*



**IEMs.** In Ear Monitors, or IEMs, are a great way to reduce the amount of gear you have to carry around and give you some direct control over your stage volume. Any kind of headphones can block some external sound. Just make sure they aren't part of the problem.

**Rest.** Your ears get tired, and after a loud concert, it is safer to allow them a period of complete silence - or at least as close as you can get. I will often sleep with earplugs in after a show to give my ears a little extra edge in recuperating, and my ears are much happier for it.

**Take Antioxidants.** There is some research that taking antioxidants before you are exposed to loud sounds has some protective effect. Your ear using them to repair damage, and making more available while the ear is dealing with the damage helps the ear do a better job. This includes easy-to-find Vitamin E, but is especially true for glutathione. Glutathione is used directly by the ear to fight damage from noise and studies show that taking some immediately before or after exposure to loud noises can help prevent permanent damage. Glutathione is available online.

## Fun Fact!

The energy from sound only truly decreases exponentially if you are skydiving. Otherwise the sound reflects off of nearby surfaces and back to you, giving you a double or triple dose of the sound. If you are playing a room with a low ceiling and concrete walls, the sound bounces back and forth, hitting your ears each time.

**Volume Limiter:** While not as practical on stage, using a volume limiter on your MP3, metronome, studio etc can help to avoid damage.

**Lighter Sticks.** Force = Mass x Acceleration. One of the simplest things you can do to reduce volume is to switch your sticks to something that weighs less. Sticks that weigh half as much result in half the power - and volume.

**Better Technique.** Let's face it: Most drummers really do play too loudly. I have been called "the loudest drummer in the world" on more than one occasion myself. It is fun to play loudly. However, it isn't always appropriate - especially on the cymbals. Becoming proficient with finger technique is a great way to



lower the volume on the cymbals - and enable some really fancy playing to boot. Besides, it is musical. The bass drum and the snare are more important for most musical styles, and deserve to be louder.

**Get tested!** Knowledge is power. If you don't know how loud the stage is, you aren't going to know the best course of action. Sound level meters are easy to come by these days - you can download an app for free on a smart phone that can tell you.

**Tell Your friends/family/bandmates.** If they don't know, they can't help.

**Eat Well.** The damage from sound will happen. Give your ears a fighting chance by eating well so they can be at their best to repair as much of the damage as possible. Eating well and drinking enough water has been shown to reduce noise induced hearing loss.

**Don't Smoke.** One of the ears' responses to loud sound is to increase blood flow to the damaged areas. Nicotine prevents this. Turns out that smokers are 70% more likely to develop noise induced hearing loss than nonsmokers.

**Watch out for ototoxic drugs.** Every over the counter pain reliever available and over 100 classes of drugs can make the ears sensitive to noise induced hearing loss. See page 166.

## Ear plugs

Ear plugs do more than simply stop up the ears. The ear canal amplifies sound much like the shell of a drum, and filling it up with something reduces volume and significantly changes the tone. The shape of the ear canal makes the sound at around 2700 Hz about 17dB louder. Filling the ear canal with an ear

### Fun Fact!

According to research, two thirds of drummers never wear ear plugs.

*Custom molded earplugs provide the highest fidelity.*



plug changes that resonance, and thus changes how we hear the sound.

This is why we love and hate ear plugs. We love them because they are the first line of defense protecting our ears during shows and practices. We hate them because they change the characteristics of the sound we hear. Because the ear plugs fundamentally change the nature of the sound before it gets to the cochlea, there isn't any way to really get high fidelity in ear plugs. Every ear canal is shaped differently, so an off-the-shelf ear plug won't be able to give you the exact right fit. Even with custom molded plugs, there is constant movement - especially from singing - that keeps the ear plugs shifting subtly within the ear. Once you get used to wearing ear plugs, your brain will do a pretty good job of making up for the difference, though. Like waiting for your eyes to adjust to the dark, it takes a little bit of time to attenuate the signal from the ears. Popping ear plugs in right before you play doesn't give your brain enough time to make the change. You might consider putting your ear plugs in before you need them. This has the added bonus of keeping the accumulated damage from loud sounds even lower.

## Tinnitus

Tinnitus is a ringing, hissing or buzzing in the ear that isn't really there. Tinnitus isn't a cause - it is a symptom of other problems and almost always accompanies hearing loss. Drummers suffer tinnitus at 3-4 times the rate of non-musicians.

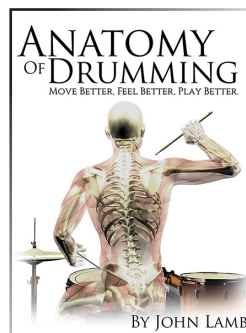
Tinnitus is a little different in everyone. For some it is a ringing, for others a buzzing, roaring, hissing or whistling. No matter the sound, it essentially prevents the sufferer from experiencing quiet. If it is severe enough, tinnitus can impede normal hearing, keep you from getting to sleep, break your concentration and/or come with a raft of negative emotions.

Nobody's quite sure why tinnitus happens, but the prevailing theory is that tinnitus is phantom limb syndrome for the ears. In phantom limb syndrome, a person feels a limb that has been removed. The cause is that while the limb is gone, the part of the brain that receives information isn't. Now left to its own devices, that part of the brain goes a bit haywire. In phantom limb syndrome the brain thinks the limb still exists in a ghost form, and in tinnitus people hear phantom sounds.

### Fun Fact!

If your tinnitus is rhythmic or matches your heartbeat, see your doctor. It could be a sign of a more serious problem. She may actually be able to hear herself through her stethoscope.

Excerpted from *Anatomy of Drumming: Move Better, Feel Better, Play Better*



## Ototoxicity

Noise isn't the only danger to the ears. Many common drugs can damage your hearing. The technical term is ototoxic: meaning they damage the sensory structures in the ear. Research suggests that ototoxic drugs may attack the ear hair cells or support cells directly and/or prevent the cells from healing themselves. Damage can range from mild tinnitus to profound deafness.

Over 1000 drugs and chemicals are known to be ototoxic. This list includes, but is not limited to, every single over-the-counter pain reliever available; Advil, Excedrin, Aleve, Motrin, Tylenol. Other widely known drugs with ototoxic side effects are nicotine, streptomycin, Valium, Paxil, Prozac, Xanax and many, many more. The the most ototoxic drugs are mostly **antibiotics** (neomycin, streptomycin, etc), **diuretics**, (acetazolamide, etc), **salicyclates** (aspirin) and **NSAIDs** ( ibuprofen, acetaminophen, etc). There are several large ongoing studies, so you can find out more information online about specific drugs.



*Every over-the-counter pain reliever can cause hearing damage.*

## Early warning signs of ototoxicity

- Dizziness
- Onset, change in type, or worsening of tinnitus
- Pressure in your ears
- Hearing gets worse or fluctuates
- Vertigo

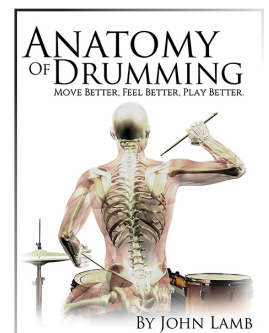
## How Dangerous Is It Really?

Nobody really knows exactly how much hearing damage from drugs there really is. There are dozens of ways that drugs could harm the ear, and most researchers aren't on the lookout for subtle and slow damage to hearing. With a few drugs, there

## Fun Fact!

Slowly built-up damage can be hard to detect. Just look at how long it took the NFL to notice the damage from head trauma.

Excerpted from *Anatomy of Drumming: Move Better, Feel Better, Play Better*



may be profound and rapid deafness. Mostly, however, the permanent damage is hard to see because it builds up slowly over time. The slowness of the damage also prevents the harmful effects from showing up in clinical trials - and thus on warning labels or doctors' textbooks. When a loss of hearing is noticed, ototoxic damage is often confused for noise induced hearing loss, old age or associated with the disease the medicine was prescribed for. Even when ototoxic damage is noticed and recognized for what it is, according to former FDA commissioner David Kessler, only about 1% of serious side effects get reported. Other research suggests this number is much too generous, putting the number closer to zero.

Complicating matters further for researchers is that much of the damage is temporary. For most of us, if we experience symptoms at all, they reverse when the drugs fade from our system. **This might be great news for you.** If you are regularly taking aspirin or other ototoxic medications, and you are experiencing hearing loss, the two might be related. You may find your hearing restored a week or so after you stop taking the medicine. Unfortunately, sometimes a portion of the damage is permanent.

Further clouding the issue is a lack of clear research standards on ototoxicity. Some researchers hold that there must be a loss of at least 10 dB in both ears before a drug can be considered to be ototoxic. Others put that limit at 15 or 20 dB in only one ear. This ought to scare you. Only a massive loss in hearing ability is counted as a side effect. Small, slowly built up damage sails totally under the radar and isn't even considered. The slow accumulation of ototoxic damage is something that is most certainly occurring but generally unknown and unlooked for. One example of the effect of varying standards is Cisplatin. Some researchers find almost no ototoxic effect, and others find it to permanently damage hearing nearly all the time. The difference is how you define the terms.

## Noise Problem

Unfortunately for drummers, there is another problem: **ototoxic drugs amplify the damage done to the ears from loud noise.** Ototoxicity messes with the ear's ability to recover from loud noises. Very few of the guides on ototoxicity mention this, but for musicians it is critically important. The volume of our instruments puts us all at risk for ototoxic effects.

**Vicodin** is a combination of hydrocodone and acetaminophen (Tylenol), was not thought to be ototoxic for many years, but is now known to cause permanent deafness if abused. High rates of consumption (over 20 pills/day) are required to cause such high levels of damage, but because Vicodin is addictive, many people end up taking high dosages. Rush Limbaugh's sudden deafness in 2001 was due to his drug addictions. Research shows that it is the acetaminophen (Tylenol) in the Vicodin - not the hydrocodone - that causes the hearing damage.

If you are wondering why it took so long to discover Vicodin's ototoxicity, the reason is simple. It takes a high dose to reach ototoxicity - much higher than was used by the FDA in researching side effects. Many side effects are dosage dependent and others take a long time to express themselves. Ototoxicity is both.



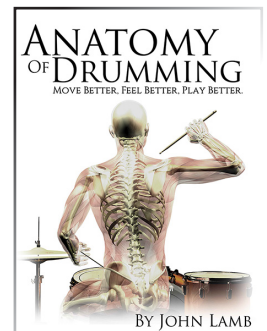
For example, one study looked at workers who were exposed to both noise and toluene, an ototoxic chemical used widely in paint thinners, paints, feedstock, etc. The workers who were exposed to noise alone had 4x the hearing loss than workers who weren't exposed to either. Those exposed to the toluene had 5x the hearing loss, but those exposed to both at the same time had 11x the hearing loss. Another similar study in Brazil placed this increased damage at over 27x.

Ototoxic drugs can synergize with noise, and they can synergize with each other, further amplifying the damage to the ear. Because there are so many ototoxic drugs, it takes extra care to avoid combining them. For example, both the nicotine in cigarettes and the carbon monoxide can damage the ear by reducing its ability to recover from auditory trauma. The damage is amplified if the nicotine and/or carbon monoxide (even second hand smoke from bars) is combined with other ototoxic drugs or loud sounds.

### **How Dangerous Is It To Me?**

To make a long story very short, it varies from person to person. Like damage from noise, some people seem to be better protected than others. Also like noise induced hearing loss, the dosage matters a lot. Low doses aren't likely to cause damage, but the chances go through the roof when you combine ototoxic drugs with loud sounds and other ototoxic drugs taken at the same time. The only way to know how you are affected is to find out for yourself.

Excerpted from *Anatomy of Drumming: Move Better, Feel Better, Play Better*



## What To Do About It

**Don't simply stop taking medicine because you hear it is ototoxic.** Speak to your doctor first about your situation to find if there is a better course of action. There may not be!

**Talk to your doctor.** Your doctor needs to know your concern about hearing loss, and should be able to prescribe non-ototoxic drugs. If your doctor is unaware of or unconcerned about ototoxicity, then you might consider switching. Be sure to let your doctor know about any existing hearing loss and that you are a drummer.

**Skip a show.** If you need to be on that antibiotic, maybe it is better to skip your show or rehearsal. No matter how much it hurts to give up the gig, the potential damage to your ears probably isn't worth it. At very least use the most powerful ear plugs available.

**Follow dosages exactly.** Don't take over the amount that your doctor or the drug company prescribes - whichever is smaller.

**Watch out for combinations of ototoxic drugs.** They can combine their effects to do extra damage. This is particularly true for loop diuretics, cisplatin, and aminoglycoside antibiotics. It is even true for nicotine and aspirin. If you use the same pharmacy, they will be able to better watch out for bad drug combinations.

**Drink plenty of water.** Having enough water protects your ears and helps to moderate the levels of ototoxic drugs in the ears - helping to keep the ears safe.

**Eat well and exercise.** When your body is healthy, it runs better - and handles ototoxicity more effectively.

**Get checked.** If you begin a treatment with an ototoxic drug, get your hearing checked with a serial high-frequency audiogram before you begin the treatment, and monitor your hearing regularly as you go along. This will allow you to detect hearing loss early and stop the treatment - saving your ears. Serial high-frequency audiogram is important because normal hearing tests won't catch hearing loss soon enough.