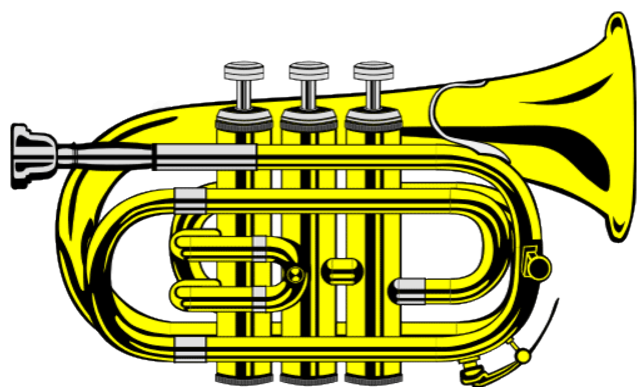
The Science of a Brass Musical Instrument.

Ever wonder why we always tune our brass instruments using the open valves (no buttons pushed)? The reason is because the natural pitch of the instrument is with no valves depressed. We tune with no valves down to set the natural pitch. When we press a valve it adds length to the tubing and it lowers the note. Any length of pipe has a natural resonate frequency. Buzz your lips on one end and you will see the longer the pipe the lower the pitch. A trombone works on this principle in that as the slide is moved out the length of the pipe, or tube, gets longer. Any brass instrument, no matter how nicely it is folded, is really nothing more than a long tube. We tune in this natural condition with no valves pushed, to set the base frequency (tone) in tune with the standard.

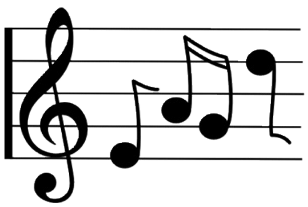
Each valve adds a different length of tubing so pressing any valve makes the pitch lower.



- The first valve moves the pitch down 1 full step.
- The middle (2 nd ) valve moves down ½ step
- The third valve moves the pitch down 1 and 1⁄2 steps.
- Pressing valves adds tubing length to the air pathway.

Using logic you can see that if you want to go down 2 steps, you would use the 2 nd and 3 rd valve together. All three valves down at the same time equals 3 steps.
If you press the 1 st and 2 nd valve at the same time you go one and a half steps, the same as just the 3 rd valve alone, thus you may play any note that is normally played with 1 st and 2 nd valves together, with just the 3 rd valve.
You might question why I say the pitch goes down, and the answer is that the natural pitch does but with our lip we may go up. Take any note and hold the valves the same and you can play many different notes, so holding down just the 1 st valve, and using our lips, we can play F, Bb, D repeated for different octaves. Every valve setting allows us to play a range of different notes. We normally play E (bottom note

on the Treble staff) with 1&2 valves, but any time any note, including E, which is fingered
1&2 can be played with just the 3 rd valve just as well. If an instrument has 4 valves, the 4 th valve is the same as 1&3 but on low notes is more in tune. Pressing the 4 th valve and the 3 rd valve at the same time opens up additional low notes that cannot be played otherwise. For example, if one plays a descending C Major scale, starting at C below the staff (low C), one of the notes (low D below the staff) cannot be played on a 3 valve instrument, but 4 &1 will play it.



Most notes can be played with several different fingerings, known as “alternate fingering”, learning this allows easier fingering in some cases where normal fingering would be difficult. For example, if I needed to jump back and forth between D (below the Treble staff) and G , I could just hold down valves 1&3 and use my lip only, because G can be played either open (no valves depressed) or with the 1 st and 3 rd valves depressed. Most notes have at least two different fingerings that can be used. Any length of tubing has a resonate frequency but due to the sound waveform and how it valves 1&3 and use my lip only, because G can be played either open (no valves depressed) or with the 1 st and 3 rd valves depressed. Most notes have at least two different fingerings that can be used. Any length of tubing has a resonate frequency but due to the sound waveform and how it relates to the resonates we are able to play other notes that are harmonically related.

Another very interesting feature of a brass instrument is the bell. On one end it starts as the same size as the tubing but it flairs out. I will not go into the great technical details and the science of the why it is this way but I will tell you that if there is no bell, the instrument would be hard to play and the sound would be awful. The instrument tubing slowly gets larger as you approach the bell. The bell makes a smooth curve from the tubing diameter until it curves to a right angle, or close to it. Here is the science part in an overview; the bell is an impedance matching device. Any sudden change in impedance causes problems. For example when you make ripples in a swimming pool they move along the surface of the water until they hit the side of the pool, then they bounce back. It gets complicated but as the waves bounce back and interact with the still arriving ripples, they add or subtract from the wave, sometimes canceling themselves out, or becoming double height, or anything in between. They bounce back because there is a sudden change in impedance, or resistance, to the flow. If there was a device that matched the impedance, the waves would not bounce, they would just disappear, giving up the energy of the wave into the matching device. These are known as “standing waves” when they bounce back. When our sound comes out of the instrument, if there was a sudden transition from the instrument to the air, there would be all sorts of bad effects, like the horn becoming hard to blow, bad sound, and who knows what, all because the sound is bouncing back on itself. The bell makes a smooth transition from the horn to the air without any sudden change, no one rough spot, so it slowly changes the impedance from the horn to match the impedance of the air. The smooth curve of the bell is critical to the sound produced. A lot of ‘dings’ in the bell can change the sound of the instrument

There is a lot of science in how a brass instrument works. It is not the horn that makes the sound, or the valves that set the pitch, they just set the environment and our lips and the vibration we make (the buzzing) is what makes the sound. It is the player and the instrument working together that make music.