The Dynamics of Breathing

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– Kevin Kelly

When Arnold Jacobs died on October 7, 1998, he left a legacy of concepts and former students that few have equalled. During his lifetime Jacobs drew an endless parade of musicians to his studio, from the obvious tuba players to professional singers and woodwind players. Because he suffered a childhood illness that left him with diminished lung capacity, Jacobs began to study the mechanics of breathing. This soon became a lifetime pursuit that was never an end in itself, just a means to play well without the hinderance of improper breathing habits. Indeed, after extensive instruction on correct breathing, Jacobs would then admonish students to just match the sound in their mind with comments such as "Have Herseth in your head" or "You must have a tape recording in your head of what you want the sound coming out of your horn to be like."

Descriptions in articles about playing wind instruments generally contain more errors than truths on how to breathe. During the late 1970s The Instrumentalist *deleted all such descriptions until it could obtain and print the definitive explanation of what moves air in and out. That article finally appeared in the December 1983 issue in a joint interview with Arnold Jacobs and David Cugell , then director of the pulmonary function laboratory at Northwestern Memorial Hospital in Chicago, Illinois. In memory of Jacobs' lifetime of achievement as a teacher and performer, we reprint substantial portions of that classic article.*

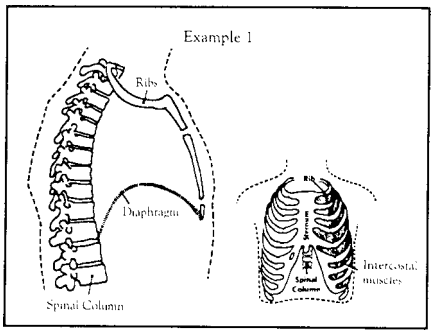
At some time every student of a wind instrument is instructed in the correct method of breathing. If he studies with two or three different teachers, he probably learns two or three different methods, all presumably correct. I studied with six horn teachers and learned five breathing methods, each slightly different and none especially helpful.

The problem is two-fold. First, few teachers fully understand how the body regulates breathing, let alone how the breath is used in wind instrument playing. Second, those who have at least a partial understanding teach it in the wrong way, through attention to anatomy. The teacher's incomplete understanding is conveyed to the student, who becomes confused, disillusioned, and perhaps even immobilized. The standard art-of-playing books for each instrument help little, because few are coherent on the subject, and even fewer agree with any other text.

In an attempt to understand this problem I conferred with two noted authorities on the subject of breathing: David W. Cugell, Bazley Professor of Pulmonary Diseases at the Northwestern University Medical School in Chicago, Illinois, who also heads the Pulmonary Function Laboratory at Northwestern Memorial Hospital; and Arnold Jacobs, principal tubist emeritus of the Chicago Symphony Orchestra and a world-renowned teacher, who is sought by students and professionals on all wind instruments, primarily for his approach to the psychology of breathing.

Wind instrument players are concerned with the creation and maintenance of a moving column of air, which is the responsibility of the respiratory muscles alone. Many of the muscles of the abdomen and chest, and some in the neck, are involved in moving air in and out of the lungs. The diaphragm is the muscle most frequently mentioned in connection with wind instrument playing and the one least understood by wind players. It is popularly considered a main element in the concept of breath support – we are often told to support the tone from the diaphragm – as if the diaphragm were active in expiration (blowing air out). It is not.

"The diaphragm is a muscle of inspiration (taking air in)," Cugell says.



"Located around and above the abdomen (see example 1), it is unique among the muscles of the body in that it contracts not from one end to the other, as the muscles in your arm, leg, or back would, but in a circular fashion, so that a contraction of the diaphragm will reduce its size while flattening it out. The diaphragm is connected to the lower ribs in such a manner that when it contracts, it moves downward. It's one muscle, but like all muscles it's made up of multiple fibers that contract synchronously. When it contracts, the effect is that it pushes downward.

"The active part of breathing is the inspiratory portion. In order to move air into the chest and expand the lungs, an active muscle effort is required, and that means contraction of the diaphragm. Now you can produce a little bit of breathing by contracting other muscles such as the strap muscles in the neck. When you see someone completing a hundred-yard dash, they're gasping and tugging with their neck muscles as well as with their diaphragm, but that's the agonal gasp of the subject who is in extreme physical activity, which is not the case when you're playing a musical instrument. You may need to breathe in a hurry or you may need a big breath, but coordinated and planned breathing is not assisted by contracting some of these other muscles, which contribute relatively little compared to what a healthy diaphragm can do."

Cugell points out that the diaphragm functions only to assist with taking the air in "It's the other muscles, particularly in the chest area and the abdomen, that we use to exhale and that collectively develop the air pressure you need to play.

"When someone sustains a high C in a proper way using the diaphragm – as opposed to someone who does it improperly – it really has nothing to do with the diaphragm. It has to do with how the person contracts other muscles in the abdomen and chest. This information has been translated into the lingo of singers and wind instrument players assuming that exhaling is accomplished with the diaphragm, when in fact it is done by contracting other muscles.

"There are two overlapping layers of muscles between the ribs called the intercostal muscles; some contract during inspiration and some contract during expiration. If I inhale in a hurry and I want to stop at a certain point, before I actually stop, the muscles that move the chest in the opposite direction begin to work. It is this interplay of the muscles that moves things in opposite directions, which provides the fine control."

Professor Arend Bouhuys of the Yale University School of Medicine, to whom Cugell referred frequently in our discussions, offers a good illustration of how the breathing-in and breathing-out muscles cooperate in wind playing:

> The respiratory muscles help to generate most of the energy that goes into playing a horn. They act on the chest, which is, for our purposes, an elastic bellows. When the chest (that is, the lungs in it) is full of air, the chest tends to collapse as it relaxes. Just try it for yourself: inhale as far as you can, relax all muscles, and exhale with a sigh. Now try the opposite, which is more difficult to do: breathe out as far as you can. Now relax all muscles, and the air flows in. The resting position of the chest bellows is somewhere in between, roughly in the middle of the volume excursion range of the chest. The respiratory muscles have to work with or against these elastic forces, depending on what the chest volume is and what pressure we need to play the horn.
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> If we first want to breathe out slowly with very little pressure, after breathing in as far as possible, we must use considerable inspiratory force to keep the air from going out with a sigh. Again, try it for yourself. Breathe in deeply, and let the air out very slowly.
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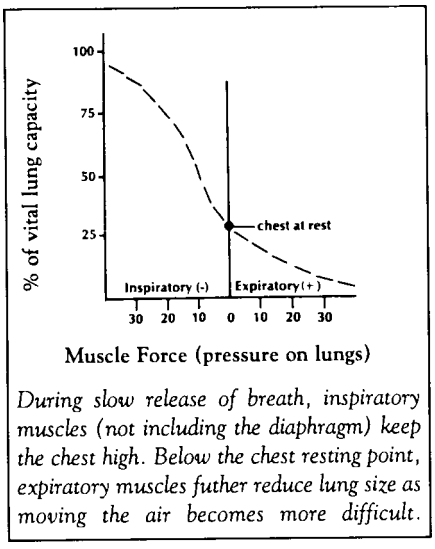
> You have to 'brake' your exhaling, using inspiratory muscles to hold back, to keep the chest volume from decreasing too rapidly because of its own elasticity. When you continue, you reach a point where you are relaxed. Now continue to breathe out slowly, and you find that you now have to push with expiratory muscles to move the air out at the same slow rate. (Arend Bouhuys, "Physiology and Musical Instruments." Reprinted by permission from Nature, volume 221, number 5187, page 1200. ©1969, Macmillan Journals, Ltd.)

The amount of control the wind instrument player has over this procedure is limited by what is called the pressure-volume diagram of the chest, which says that greater pressure is required to move air at volumes below the resting lung volume than at volumes above the resting point. As Cugell explained it, "In the lung the pressure-volume relationship is linear over the mid-range – that is, I get equal volume increments for equal pressure increments. Once I reach the elastic limit, no matter how much pressure I apply, I don't get any more volume.



During slow release of breath, inspiratory muscles (not including the diaphragm) keep the chest high. Below the chest resting point, expiratory muscles futher reduce lung size as moving the air becomes more difficult.

"With no conscious effort to facilitate things, the pressure is greatest when the lungs are largest. Similarly, when the lungs are largest, the conscious contraction of the muscles produces the highest pressures. Active expiratory effort is, of course, needed whenever the required mouth pressure for the instrument is higher than the relaxation pressure at the prevailing lung volume. As the lungs get smaller, they are no longer going to contract and generate pressures on their own. You have to do it by squeezing with the muscles.

"For example, if you inflate the lungs to their absolute maximum and then play a high C on the trumpet at maximum volume, you haven't used much air, but the volume of air in the chest is reduced considerably because you've had to squeeze so much. You compress the air in the chest just as much as the air in the mouth. Whether you have an instrument that has a low pressure, for which you're going to need a high air flow to get a large sound, or you're playing an instrument that has a low flow at enormous pressure (one that uses a small mouthpiece), the effort required of the player is essentially the same. In other words, you've got to squeeze with the muscles to generate either a high flow or a high pressure.

"The vast difference is that if you don't need much pressure you can play with the entire usable portion of the lung volume. However, if you need a lot of pressure you can only use a small portion of the lung capacity because when the lungs are partially empty it's not possible to generate the pressure, as shown in example 2. You can generate the maximum pressure when the lungs are full, and you want to do that to play a loud, high note; but after you've exhaled some air, the lungs are smaller and then it's not possible to sustain as high a pressure. So there is a limited period of time when a player has both the volume and the pressure to produce the sound. On the other hand, the time during which an oboist can sustain a note is not limited so much by the air pressure and air flow requirements of the instrument as by his breath-holding time. If you don't need much pressure and you don't need much flow, then you've got all day; but there's only so long you can hold on before you've got to breathe again."

The point that Cugell insisted upon throughout our discussions is that, given all the facts of breathing anatomy, each player will discover the practical applications for himself. The compensatory pattern of breathing that people spontaneously adopt will represent the minimum work that is required, and it is probably incorrect to impose a different pattern. I think a person playing a wind instrument fits into the same category. If he's got to grab a breath between two passages, he's going to do it in a way that's best for him; I doubt

that there would be any purpose in imposing a different pattern. If the player did it once and ran out of air, the next time he's going to breathe a little more because he knows he has to.

Cugell referred to the Nature article, which describes the test Bouhuys conducted on four flutists playing Debussy's Syrinx. One of these men was first chair in the Concertgebouw Orchestra of Amsterdam, one was a good amateur, and two were young professionals. Recordings from a pneumograph (an instrument designed to measure chest movement during respiration) showed four slightly divergent readings within the same general pattern, with slight tempo fluctuations. With the exception of one man, who had a slightly smaller lung capacity and took one extra breath, the performers adhered to the phrase-breath markings in the music. This test showed the extent to which the music determines a player's breathing pattern. "So if we subscribe to the concept, with respect to instrument playing, that we will spontaneously assume the most efficient and effective pattern," says Cugell, "then it certainly makes good sense not to concern yourself with it so you can concentrate on all the other aspects of your playing."

Anatomy and Psychology

Arnold Jacobs bases his teaching on all these other aspects of sound and phrase – the products of music. He makes the distinction between anatomy and function through what he calls the computer activity of the brain, which is separate from the thinking part of the brain.

"When you go to the product of whatever you're trying to accomplish, you'll find the physical action required to do it is based in the computer activity of the brain. In other words, the conscious levels of the brain, where volitional thought takes place, handle the product. Another level of the brain, the thinking part, will handle motor impulses carried by nerves throughout the body. The firing up of the systems is handled at subconscious levels, just like the ability to walk or to talk or to run. The muscle activity will result from what you're trying to accomplish. With all machines there is a set of controls, like an automobile, which has complex machinery under the hood but simple controls in the driver's compartment. There's nothing as complex on this planet as the human being; but man has magnificent controls, and he functions through this control system.

"By this I mean that there are divisions in the brain that are going to control all sorts of physical functions: cutting up food, bringing it to the mouth and chewing it, handling the body for sleep at night, or even going insane. The thinking part of the brain is free to cope with life around us, it does not have to cope with life within us. It's with the thinking part of the brain that we begin to establish what we want in the way of product.

"This, of course, is what players are up against; in music, so often a teacher makes the mistake of altering the machine activity rather than altering the product or what he wants accomplished. The instructor is giving machine methods of how to do it, and people can't work that way. None of us can. We have to look for the easy answer all the time. It is so simple. If you want a lot of breath, just take a lot of air. Don't worry about where it goes. If you want to blow, just blow. With students a teacher should always try for the simple answers that bring out the proper motor response. That idea belongs not in the realm of anatomy but in psychology."

The concept that Jacobs introduces students to is what he calls the "phenomenon of wind" – the idea of blowing air out through the instrument to prevent pressures from building up inside the lungs. Most students who come to Jacobs have acquired the habit of thinking about air pressure instead of air in motion. Because these habits are difficult to break, he uses psychology to create new habits, to get students to use their muscles for the proper function.

The respiratory muscles are involved in three ways. One is respiration, the single complete act of breathing in and out. The second has to do with pelvic pressures when the upper end of the airway is closed, forcing pressure downward for such events as defecation and childbirth. The third has to do with the isometrics of physical function, the kind of static muscle tightening invoked in weightlifting and wrestling.

"A musician has to make sure that he is using the right approach when playing an instrument," Jacobs says. "He doesn't want the one that immobilizes, and he doesn't want the one that creates great isometric contractions that have no movement potential. Because a continuous flow of air requires movement, the player should go to respiration.

Move Air as Wind

"The psychology of blowing is always to blow outward, to work with wind rather than air pressure. The psychology of it is important. Take your hand, hold it at a distance, and blow onto it. Now where the air lands is the area to concentrate on. Some teachers will have the player blow through the instrument or through the far wall. It doesn't matter what the technique is to motivate a student; the psychology of it is to move air as wind, not air pressure.

"With wind there is always air pressure. With air pressure, there is not always wind. If you just concentrate on the air pressure – which can happen in any body cavity – the danger is that you may have stimulated the Valsalva maneuver (in which you try to breathe out with your mouth and nose shut) or the pelvic pressure syndrome, or the isometrics, which do not involve movements of air.

"But an instructor is never going to get this idea across by telling students to push with this muscle or that muscle. I get them to blow. Away from the instrument I let them observe their body. I use special equipment, or I may have students blow up balloons or blow out matches, and then show how quantities can be taken from any part of the thorax (the body area between the neck and the abdomen). In other words we go through a certain amount of perspective training away from music to become acquainted with the body, so that the studies of air in life are involved."

The confusion of many teachers about both the role of the diaphragm and the idea of abdominal support of air is largely responsible for many students' preoccupation with the kind of pressures resulting from misdirected muscular tensions. "First of all, the term support raises questions in itself. Many people make the mistake of assuming that muscle contraction is what gives support. The blowing of the breath should be the support, not tension in the muscles of the body, but the

movement of air as required by the embouchure or the reed.

"You go into the mechanics of movement and confusion arises; it's a cause and effect relationship. When a player blows, the body undergoes certain changes. There will be increasing palpable tensions that can be felt just by touching a person. Toward the end of a breath, there will be a certain number of fibers that are stimulated. There will be increasing motor activity in order to get the air out, and this varies according to the length of the phrase and the amount of air in the lungs originally; but support is never tight muscles, whether you're silent or blowing, or in a diminuendo or crescendo. In other words it's simply a static, constant, isometric type of contraction that so many people call support. This is not support at all.

"Support is always a reduction phenomenon. Wherever the player is going to build pressure, according to Boyle's Law, he is going to have a reduced chamber. Now the chamber can be reduced anywhere it is enlarged. It gets bigger when you take air in, it gets smaller when you move air out. When you blow, the brain will deactivate the diaphragm, normally. Expiratory function will normally deactivate inspiratory function. If you are using air to create pelvic pressures, the diaphragm will not deactivate – it will remain stimulated. Abdominal muscles that would normally be expiratory will start contracting, and there will be a closure at the throat, tongue, or lips which causes the air pressure to bear down on a downward-contracting diaphragm to increase the pelvic pressure for expulsion of fecal matter. Of course, to bypass this we have to have a blowing phenomenon that is different. You see, you have to form a new habit, and a new habit does not come right away. A new habit takes time to reach the subconscious level."

Jacobs uses a wide variety of nonmusical exercises to get players to feel and hear the difference between blowing air out freely and blowing out in a choked manner that results in a tight chest and abdominal muscles. For example, blow onto the back of the hand using a tight hissing sound through your teeth, as loud as possible. You will feel very little air. By blowing out freely onto the hand, you feel a considerable amount of air under low pressure. The hiss is under high pressure, but there is little quantity. By closing the lips in the midst of the hiss and then releasing the sound explosively, you will have felt considerable pressure behind the lips and also behind the tongue. As soon as you open the lips, you have an immediate shortage of air.

"We see these closures in students all the time," Jacobs says, "coming from a sibilant 's' (the hissing sound) or at the back of the tongue, and even some where the larynx and epiglottis start to come together. If I have a student whose tongue is blocking the air, allowing very little air movement but at high pressure, I immediately encourage using an open vowel form such as *oh* or *ah*. All through life you have language; language involves the tongue. Over the years you have built up reflex response for shape that is very powerful. You hear a trumpet or a bassoon, but it sounds like a singer singing *oh*. Listen for that sound and the tongue shape will be correct. This pertains to any need to open up the airway."

Following one of Jacobs's recent

masterclasses at Northwestern University, a woman asked how to help a bassoon student who lets the air get "like a brick wall" – constricted and tense – which apparently resulted in quite a horrible sound.

"First of all," he said, "get her away from the bassoon. You don't have to use the reed; just put something in her mouth. Have the student start blowing or start blowing against something in order to see that the air will do something where it lands. The importance of this approach is not to correct what's wrong, but to establish what should be right.

"I would give her a couple of straws and have her blow at the pages of a book and watch what happens on the other side. Have her blow at some matches or blow up a weak balloon, but always with the thought of becoming acquainted with air, rather than air pressure. Studying childbirth and coughing gives the picture of what air pressure will do. However, when you study a burn and cool it by blowing on the hand, or when you're doing what I used to do, blow peas at people with a pea shooter, then you get a different picture of what air will do.

"Start mechanical movements without the instrument so the student experiences change in the abdominal-diaphragmatic relationship. Deliberately have her create massive motions in the abdominal region, sucking the belly in, forcing it out, pushing it up and down – this is the region where she's been stabilized. Now deliberately destabilize it. Start the muscle activity of change in front of a mirror so the senses work together to strengthen each other. Don't tie it into music, though, or else she'll have to fight her own habits.

"Then tie in the movements of air by using motion – every day – blowing out matches, taking in lots of air and enlarging. Allow a few weeks, where she has to be practicing this every day. In the abdominal region where the student was stable, she will begin to establish mobility of function. It has to be recognized in this manner before you apply it to the bassoon. Then you do it with just some reed squawks, but with exaggeration.

"Exaggeration is one of the important tools. Doing things just right is not what you want. The recognition is not there so you overchange. You're not doing it with the music, so there's no damage.

It's the Tone

"But wind is finally only a minor part. Tone production is the major. You use the wind as fuel. With a wind instrument, the horn resonates sound waves; it's reacting to sound and amplifying it according to acoustical properties. Our air isn't used to fill an instrument, it's used by the embouchure as energy so the lips can vibrate.

"So players certainly shouldn't worry about the air, but about the quality of tone. When you get the tone, you will have all the requirements of tone; you will have all the requirements of tone at the subconscious levels. The blowing is an incidental part; the tone doesn't exist without the blowing, but the blowing can exist without the tone. As an artist you go for the product – the product is sound and phrase and all the emotions in music – you use thought processes that stimulate motor function, but you don't worry about the function. You worry about the sound. You will use the breath as needed. You will do it primarily without awareness of air. The air should be used freely – waste it, do anything you want. A player's awareness is of the communication of sound to whoever he is talking to."

There are, of course, many ways students and professionals have of inhibiting their ability to express sound freely.

Probably the most common is poor posture. "Posture is very important," Jacobs acknowledges. "We're structured so that the maximal use of air comes in the standing posture, as if you would run or fight for your life. Standing offers the greatest ability to move large volumes of air in and out of the lungs. The closer you get to the supine, the poorer it becomes.

"There is no such thing as a full breath without the use of the sternum (the compound ventral bone and cartilage that supports the ribs). If I lean back on the chair and reach over my head, the motion pulls the rib cage up, which is already in the expanded position. That means I can't use it for breathing in or out. If I bend forward over my belly, pressure in the abdominal region under the diaphragm is such that 1 have great difficulty using diaphragmatic function.

"If you need large volumes of air, you will use the entire respiratory system. If you're playing an instrument that doesn't require as much air, you're never going to use a full breath; however, you should be able to. Performers have to take sufficient air in to be able to complete phrases. This involves taking in quantities of air based on judgements of how much air will be left at the end of a phrase. Standing while seated is the best posture because players have the greatest ability to move air in and out of the lungs. However, if you are breathing with comfort, the posture doesn't have to be that way. As long as you are in the upright position, you should have more than enough air. If you're a large person with large lung reserves, posture is not that important; however, people who have small lung volumes must stay upright and make use of whatever nature gave them.

"In this art form," Jacobs concludes, "we are dealing in sound. Respiration is made too much of. We need sufficient quantities of fuel so that we can use it easily – as I say, waste it, it's free – but don't make a big deal out of it. We don't start anything with skill; skill is developed over a period of time in spite of yourself. We have to recognise what we're trying to accomplish; the orders that come from various parts of the brain must be based on the sound of the instrument. We have to make sure that we don't take the level of the brain at which we have volitional thought and try to take charge of the human machine through its individual components. We can't handle it. You've got to get out of the way and allow your body to function for you. The point is to try to sound great when you play."

– Kevin Kelly earned degrees in music criticism and English at Northwestern University, where he played horn in the major wind performance ensembles.