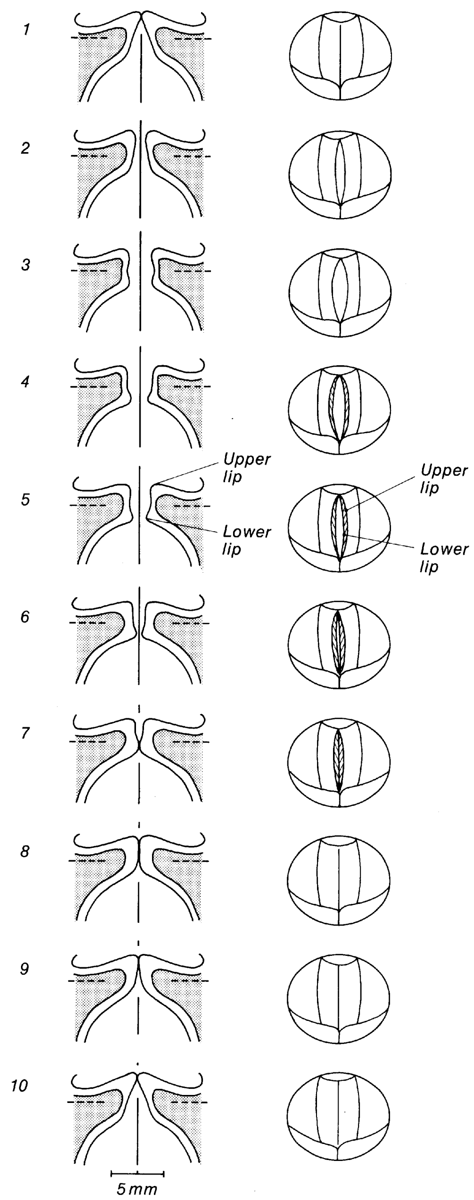
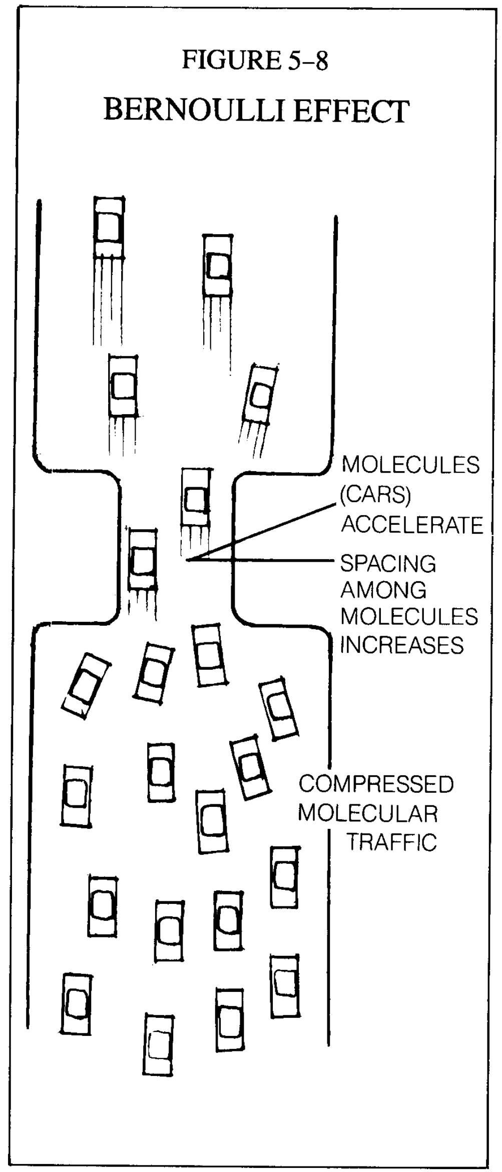


Hoole, Physiologie.

Abbildungen und Texte zu den Themen Vibrationszyklus, Bernoulli-effekt und myoelastische-aerodynamische Theorie.

Linke Abbildung aus Hirano, 1981.
Linke Spalte, von vorne; rechte Spalte von oben.
Gliederung der Stimmbänder in “***Cover***” und “***Body***”!
Klicken Sie hier, um den Ablauf als Animation zu sehen.

Rechte Abbildung aus Perkins & Kent.



Aus Perkins & Kent, Kap.5, S. 95-99

Vibratory cycle. To understand how voice is produced requires that you understand a single vibration of the vocal folds, the *glottal cycle*. It is the basic building block of voice. Generally, it is described as beginning when the subglottal pressure overpowers fold resistance just enough for the vocal folds to first start to blow open. They continue to blow apart during the *opening phase* until the escape of air reduces subglottal pressure enough for fold resistance to overpower air flow. At that point, the *closing phase* begins as the folds move toward each other. It ends as soon as the glottis is closed (or as nearly closed as it will get during the cycle). During the remainder of the cycle, the glottis is closed while subglottal pressure builds up to start the entire cycle over again (Fig. 5-5). Two ratios have been devised to describe features of this cycle. The *speed quotient* (SQ) is the ratio of the durations of the opening phase to the closing phase. Note that during both of these phases, the glottis is open. The ratio of the duration of this period of openness to the duration of the entire cycle is the *open quotient* (OQ). In normal voice, the period of openness is followed by a closed phase in which the folds are together. During this closed phase, subglottal pressure rises. In some types of voice, however, as in production of a breathy tone, the glottis never closes completely. When this happens, there is one long *closing* phase, but the *closed* phase never occurs. In these instances, SQ reveals more about the glottal cycle than OQ[1].

The closed phase is a period during which the vocal folds absorb the impact of their collision when they slam together. Presumably, the duration of this period of closure depends on how forcefully the folds collide, and how absorptive the folds are of this force. Were the vocal folds like two steel balls, they would hit and immediately bounce apart. There would be no closed phase when they were together for any period. Instead, they are compliant, more like rubber balls. The more compliant they are, the more they absorb the impact, and the longer they remain closed (Fig. 5-6).

Not only can the vocal folds vary in compliance (and hence in how absorptive they are of impact force), they also vary in complexity of vibratory motion. They begin the opening phase by blowing upward and outward. They open from

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[1] You may have discovered that there are two conditions under which the glottis is opened. One is when the arytenoids are abducted for breathing and voiceless sounds, the other is when the arytenoids are adducted for phonation and the cords are blown open by subglottal pressure. During a glottal cycle the arytenoids remain adducted in a phonatory position.

bottom to top and close from bottom to top. This creates what is called a *vertical phase difference,* as is shown in Figure 5-7. They also typically open from back to front and close from front to back, as in Figure 5-7. But in some people the motion is reversed; the opening spreads from front to back, and closes from back to front. Still another vibratory complexity is the motion of the mucous membrane covering the true folds. This loosely attached membrane tends to undulate in waves during phonation like jelly being shaken. In fact, the mucosa apparently vibrates more than the vocalis muscle, and the mucosa may be more essential to phonation than the muscle, which seems to function mainly to control shape of the vocal fold. All of these motions are difficult to study, so their effects on voice are not well understood. Yet, enough is known from computer simulation of phonatory motions to know that vibration would not occur at all were it not for vertical phase differences in the vocal folds, particularly in the mucosa, during the glottal cycle.

Vibratory Forces. What are the forces that operate in a glottal cycle that determine when and where the vocal folds will separate, how quickly they will open, how quickly they will close, and how long they will remain closed? The best unified answer to this question is the *aerodynamic-myoelastic theory* of phonation. The essence of this theory is that glottal vibration is a result of the interaction between aerodynamic forces and vocal fold muscular forces. The aerodynamic forces at work in phonation make sense only if you understand the so-called *Bernoulli effect* (the effect of the Bernoulli principle bearing the Swiss scientist's name). Your life is full of encounters with this effect which, if you have thought about them, may seem puzzling. It is the effect that gives "lift" to an airplane wing, and that pulls air out of a car window when a wind-wing is open. Stated briefly, the Bernoulli principle (which physicists call the venturi effect) is that, as velocity of a gas or liquid increases, pressure decreases. This principle is not difficult to grasp if you think of the trachea and laryngeal airway as being analogous to a freeway, and of the molecules of air as analogous to cars on the freeway. Add to this analogy the knowledge that the closer together molecules are compressed, the higher the pressure. Now all you need do is to recall that the closer together the cars are, the slower they move (Fig. 5-8). Conversely, the faster they move (the faster the air velocity) the farther apart they will be spaced (the lower the pressure). Thus, the faster the air flows through the glottis, the farther apart the molecules, so the less force they will exert against the vocal folds to push them open.