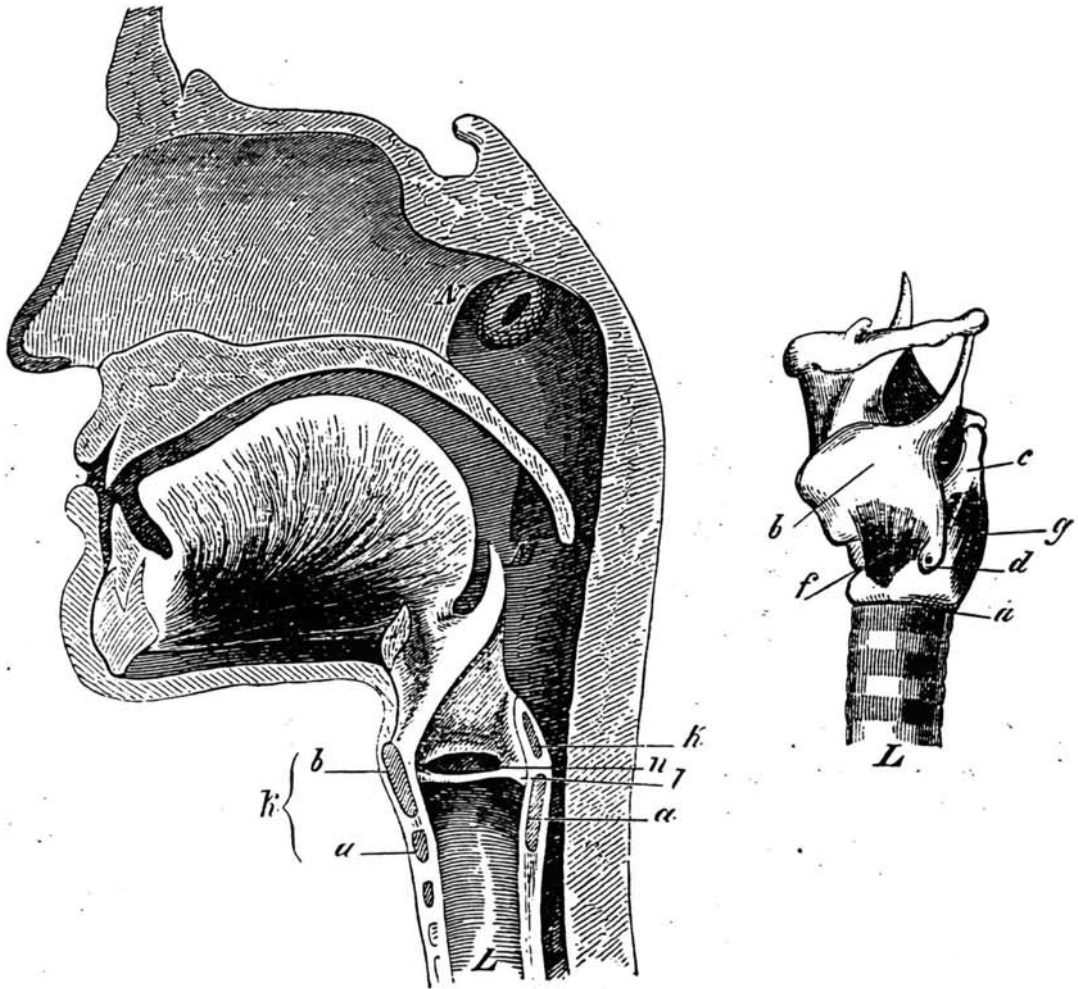


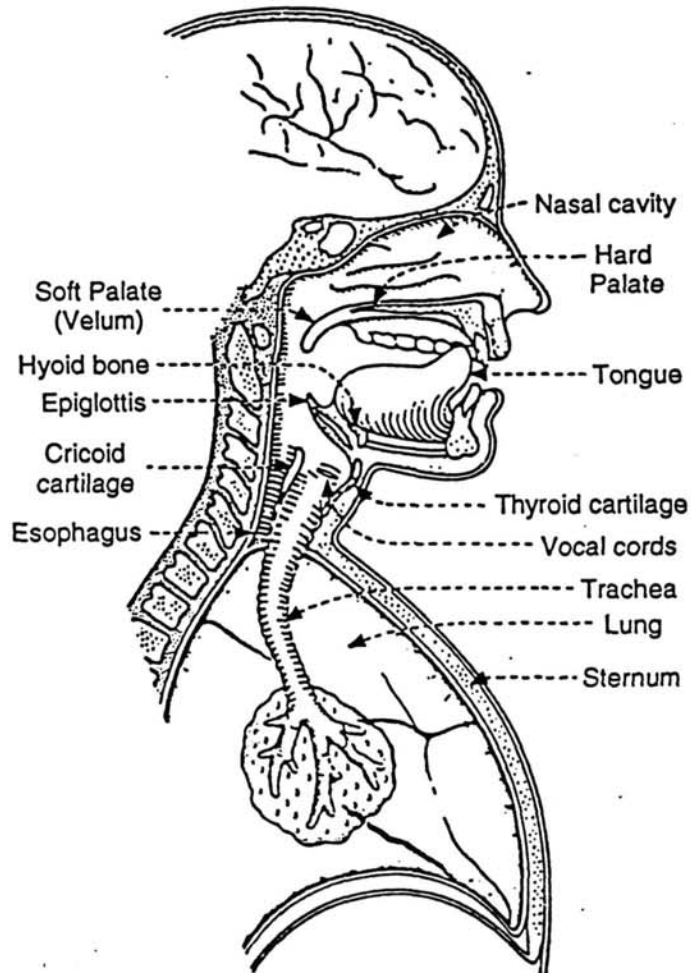
# 4. THE ACOUSTICS OF THE BODY

## 4.2. THE PRODUCTION OF SPEECH



Speech sounds are produced by modulation of outward flow of air exhaled from the lung, through the trachea, and oral mouth cavities.

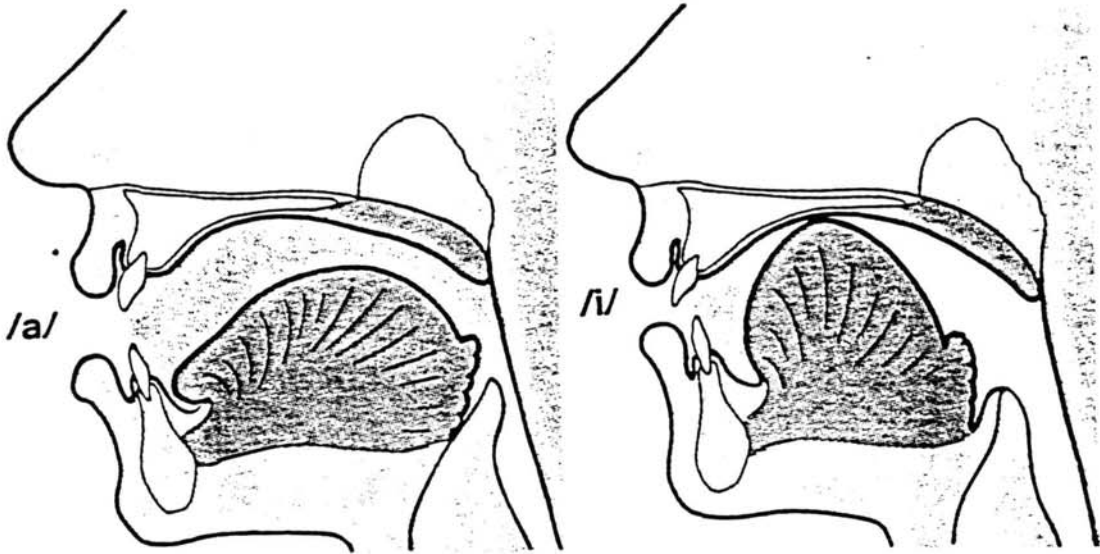
⇒ Speech can only be produced while exhaling!



- exhaled air passes through glottis (vocal chords).
- muscle controlled contraction of glottis triggers modulation process: origin of pressure variations in the exhaled air.
- mouth cavities function as resonator to give sound the characteristic modulation of voice.

Sound modulations are produced by changing volume of resonating cavities.

**a, e, i, o, u, :** voiced sounds  
rely on changing resonator volume only!



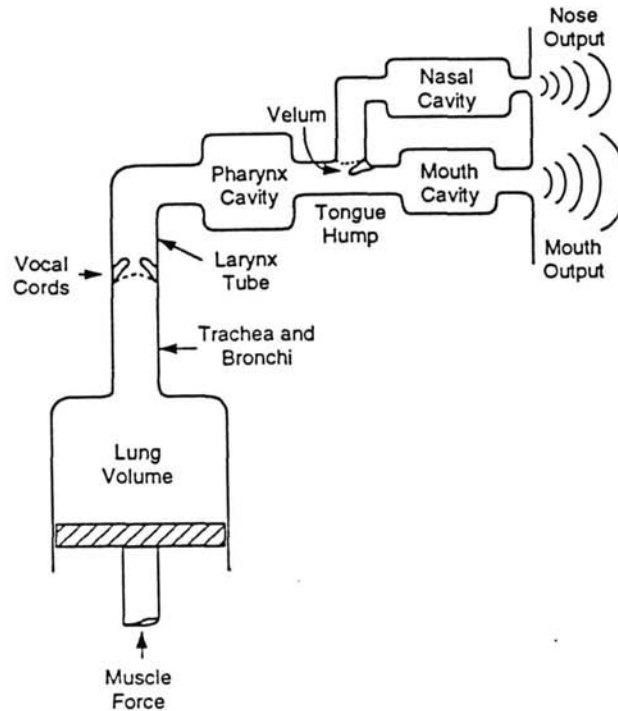
Non-voiced sounds require supporting movement of tongue and/or lips!

**s, f, th, ch, :** frictive sounds  
rely on increase of friction for exhaled air through tongue and/or lips!

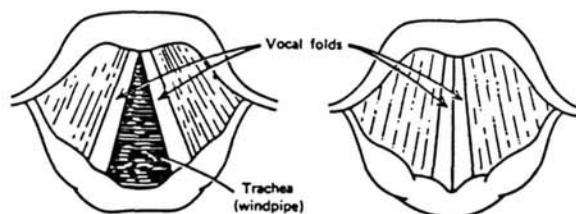
**p, t, k, q, :** explosive sounds  
rely on build-up and sudden release of pressure in the oral cavities!

# PHYSIOLOGY OF VOCAL SYSTEM

Simple model of speech production.

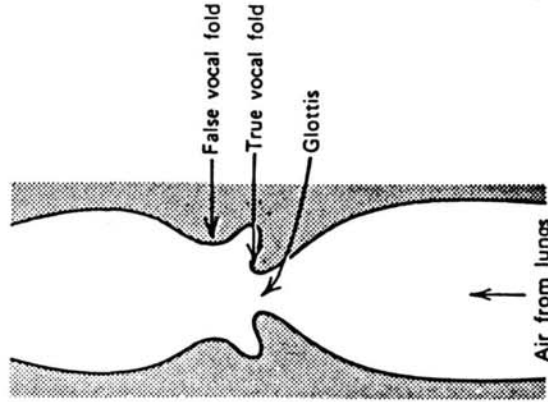


1. Glottis closed by muscle force: → increase of air pressure inside trachea,  $P_{trachea} \approx 600 - 2000$  [Pa]
2. pressure opens glottis: → decrease of air pressure inside trachea



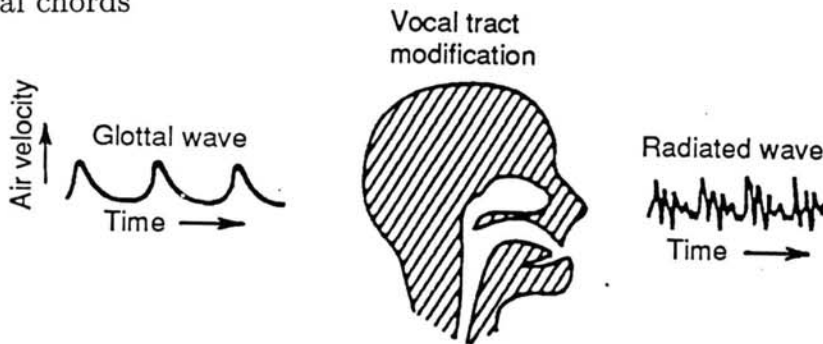
3. originates airflow through opening according to Bernoulli's law

$$P_{trachea} + 1/2 \cdot \rho \cdot v_{trachea}^2 = P_{glottis} + 1/2 \cdot \rho \cdot v_{glottis}^2 = \text{constant}$$

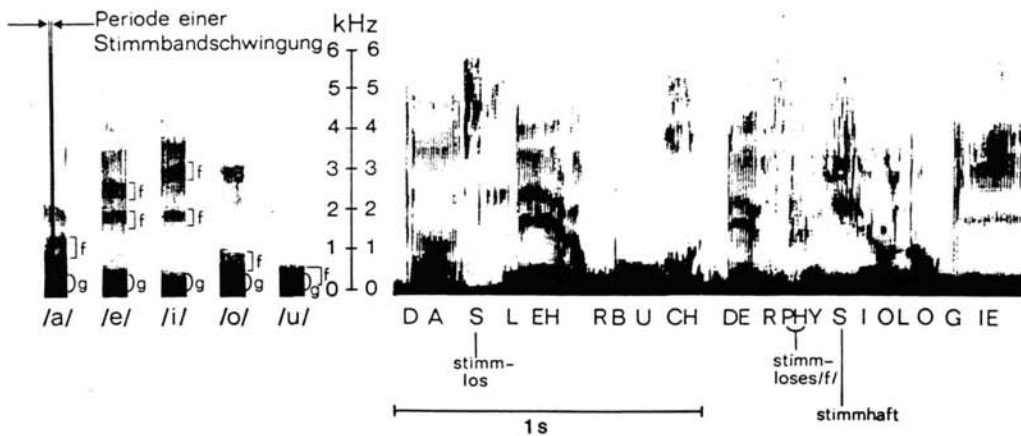


4. associated decrease of pressure causes closure of glottis

5. pressure modulation in exhaled air, fine modulation by vibrations in vocal chords



6. articulation in resonating mouth and nose cavities



Voice characteristics is determined by volume and design of oral cavities.

## EXAMPLE

How much acoustical energy is required to teach for 75 minutes?

Average frequency of speech is  $\approx 1000$  Hz (for bass)  $\rightarrow$  corresponds to frequency of vibrating vocal chords!

power in vibrating vocal chords  $\approx 15 - 25 \mu\text{W}$

Talking for 75 minutes requires a total energy of:

$$E = (15 - 25)[\mu\text{W}] \cdot 4500 [s] = 0.068 - 0.113 [J]$$

required acoustical energy is small!