General: redistribution of gas may occur in the lung after gas flow has ceased at the mouth. This is because differing airways and alveoli have differing resistances and compliances which determine how quickly, and by how much, they fill.

Time Constants:
- mathematically a time constant is used to describe the rate of change of an exponential process
- it is the time at which the process would have been complete had the initial rate of change been allowed to continue
- numerically it is the time required for an exponential process to reach 63% of its final change.
- an exponential process, as the flow of air into a lung unit, is 95% complete after three time constants
- in relation to lung units time constants are defined as the product of compliance and resistance

\[ T = C \times R \]

where:
- \( T \) is time constant
- \( C \) is compliance
- \( R \) is resistance

- refers to the time taken for a lung unit or alveolus to fill with gas
- if an airway has high resistance the movement of or air into or out of that lung unit will be slower
- this will cause slow filling during inspiration and may even not be complete before the lung has begun to exhale
- if a lung unit has a lower compliance than normal, the flow of air into that unit will cease sooner than in other units
- thus resistance and compliance of a lung unit affect the time-dependent filling or emptying of that unit
- this can be expressed as the time constant of the lung unit
- lung units with high resistances will have longer time constants and take longer to fill but units with low compliances will fill and empty quickly
- the converse is true for units with low resistances and high compliances

Fast & Slow Alveoli:
- “fast” alveoli are those alveoli with short time constants and refer to alveoli that take a short time to fill and empty (i.e. fill up fast)
- seen in lung units with low resistances and low compliances
  - e.g. pulmonary fibrosis
- “slow” alveoli are those alveoli with long time constants and refer to alveoli which take a long time to fill and empty (i.e. fill up slowly)
- seen in lung units with high resistances and high compliances
  - e.g. asthma

**Effects of Ventilation:**
- uneven time constants within the lung will effect ventilation
- partially obstructed lung units will fill more slowly during inspiration and therefore will continue to fill after the rest of the lung has stopped moving
- indeed at the beginning of expiration the abnormal region may still be inhaling while the rest of the lung has begun to exhale with the result that gas moves into it from adjoining lung units - so called pendelluft (swinging air)
- as the breathing frequency increases the proportion of the tidal volume that goes to the partially obstructed region becomes smaller and smaller
- thus, less and less of the lung is participating in the tidal volume changes and therefore the lung appears to become less compliant

**Measuring the Effects of Heterogeneity of Time Constants:**
- capnography
- peak vs. plateau airway pressures