Low versus High Diffusion Capacity Lungs

Frog  Lizard  Alligator

No cell is more then a few micrometers away from a tracheole.

Larger trachea can be ventilated with unidirectional flow.

System works well - insect flight muscle is one of the most metabolically active tissues.

Lack of convection in tracheoles limits size in insects?

(from Hickman & Roberts, 1995)

www.the-aps.org/press/conference/vabeach/11.htm
Integrating ventilation with locomotion.
Oblique axial muscles stabilize long-axis torsion.
Costal constraint on ventilation.
Breathing with a buccal pump in a walking lizard.

Data shown in red were collected when the buccal pump was disabled by propping the mouth open.

Minute ventilation

Oxygen consumption

Costal constraint

Owerkowicz et al., 1999
Intercostal muscle activity in trotting dogs

Trotting dog

Coupled

Uncoupled

0.5 s
Ensemble averages of EMG

Average of 15 cycles

Locomotor function of intercostal muscles is dominate in dogs.

Stride and breath uncoupled

Trotting dog

Locomotor function of intercostal muscles is dominate in dogs.
Mammals are derived from group of reptile-like amniotes called pelycosaurs.

Pelycosaurs resembled modern lizards.

- long powerful trunk
- short sprawling limbs
- long heavy tail
- well developed ribs - aspiration breathers
Mammalian diaphragm

Lateral view of jackrabbit

Ventral view of human

Trotting dog

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<table>
<thead>
<tr>
<th>Esophageal Pressure (cm H2O)</th>
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<tbody>
<tr>
<td>Cural Diaphragm</td>
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<tr>
<td>Costal Diaphragm</td>
</tr>
<tr>
<td>Transversus abdominis</td>
</tr>
<tr>
<td>Footplant</td>
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</tbody>
</table>

Ainsworth, Smith, Henderson, Dempsey, 1996
Crocodilians have sprawling posture and walk with lateral bending of the trunk.

Ainsworth, Smith, Henderson, Dempsey, 1996
Diaphragmatic muscle and kinetic pubic bone of crocodiles.

American Alligator
Sprawling posture requires a moment at the proximal joints.

**FIGURE 9.34** Change in the role of the shoulder girdle with change in limb posture. (a) Sprawled posture brings a medially directed force toward the shoulder girdle, conferring on medial elements a major role in resisting these forces. (b) As limbs are brought under the body, these forces are directed less toward the midline and more in a vertical direction. This position of the limbs might account for loss of some pectoral elements in phylogenetic lines in which limb posture shifted.
Trotting mammal

Reduced lateral moments

No lateral bending of trunk.

Gallop helps pump air in and out of lungs.
Sagittal flexion of back in bounding gaits.

In galloping horses, flexion of the back could displace a sufficient volume of air to drive ventilation.
Young, Alexander, Woakes, Butler and Anderson, 1992

Ventilatory systems have natural frequencies.

Cranford and Kampe, 1971
Guinea fowl -

- resonant freq. of respiratory system = 7.12 Hz
- panting freq. = 6.67 Hz
- preferred step freq. = 6.73 Hz

Reactance = compliance + inertance. From 0 to 7.12 Hz the system is characterized by compliant elements, whereas from 7.12 to 32 Hz the system is characterized by inertial elements.

Nassar et al., 2001