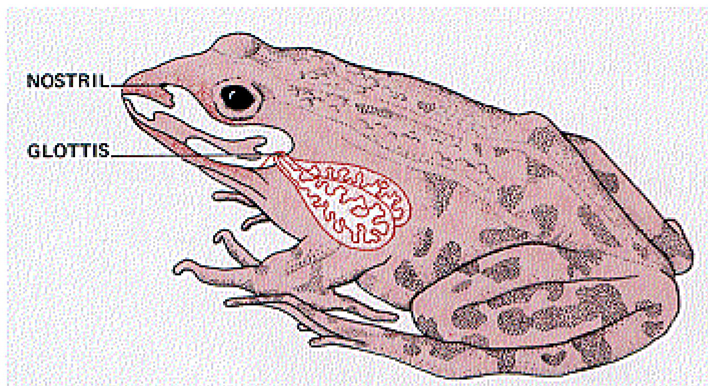
Vertebrate Lungs

Terrestrial vertebrates (**amphibians**, **reptiles**, **birds**, and **mammals**) use a pair of lungs to exchange oxygen and carbon dioxide between their tissues and the air.

Frog Lungs

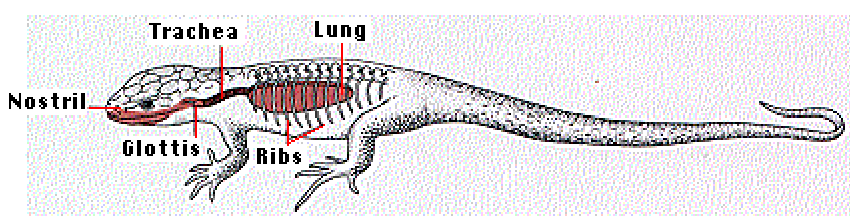


The frog's lungs are a pair of thin-walled sacs connected to the mouth through an opening, the glottis. The surface area of the lungs is increased by inner partitions which are richly supplied with blood vessels. The frog inflates its lungs by

- filling its mouth with air
- then closing its mouth
- closing the internal openings to its nostrils
- opening its glottis
- raising the floor of its mouth thus forcing air into the lungs.

The frog's skin serves as a supplementary organ of gas exchange. However, it must remain moist to do this, which is one reason that frogs, like other amphibians, live in moist places.

Reptile Lungs



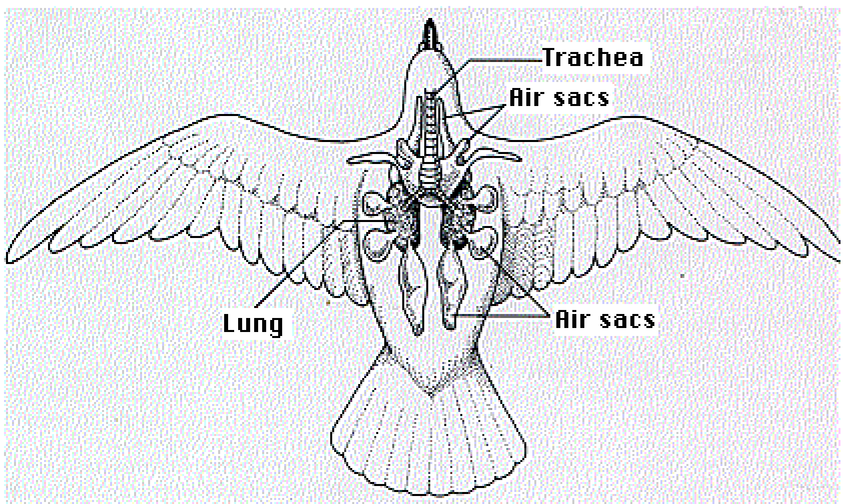
The skin of reptiles is dry and scaly, so they can live in arid locations (although many do not). However, they cannot use their skin as an organ of gas exchange. Reptiles depend entirely on their lungs for this.

Their lungs are considerably more efficient than those of amphibians.

- They have a much greater surface area for the exchange of gases.
- They are inflated and deflated by the bellowslike expansion and contraction of the rib cage.

While fresh air flows in and stale air out of the lizard's lungs, another reptile, the American alligator, uses a more efficient mechanism similar to that described below in birds.)

Bird Lungs



Unlike reptiles, birds are homeothermic ("warm blooded"), maintaining a constant body temperature (usually around 40°C) despite wide fluctuations in the temperature of their surroundings. They maintain their body temperature with the heat produced by muscular activity. This depends, in turn, on a high rate of cellular respiration. So the demands on the gas-exchange efficiency of the lungs of a small, active bird are great.

Although the ventilation of bird lungs is similar to that of reptiles, their effectiveness is increased by the presence of **air sacs**. Although no gas exchange occurs in the air sacs, their arrangement increases the efficiency of lung ventilation by enabling fresh air to pass in one direction through the lungs during **both** inhalation and exhalation.

The air sacs also aid in reducing the density of the body by substituting air for tissue or fluid in many places. Even some of the bird's bones are penetrated by air sacs.

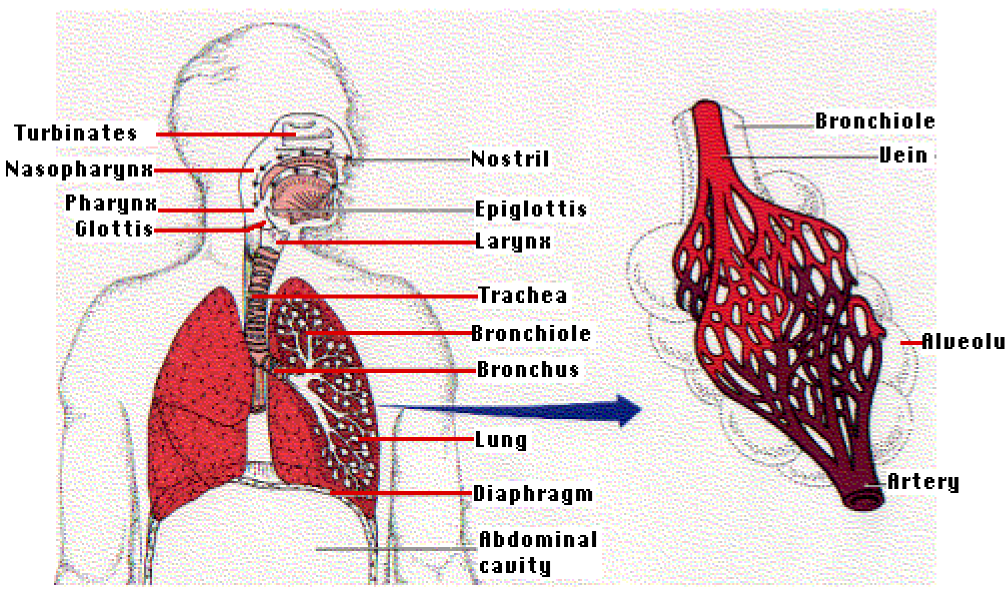
Mammalian Lungs

Ventilation of mammalian lungs is assisted by the **diaphragm** - a muscular partition that divides the thoracic cavity from the abdominal cavity.

The anatomy and physiology of mammalian lungs is described below (using humans as the example) :

The Human Respiratory System

The Pathway



- Air enters the **nostrils**
- passes through the **nasopharynx**,
- the **oral pharynx**
- through the **glottis**
- into the **trachea**
- into the right and left **bronchi**, which branches and rebranches into
- **bronchioles**, each of which terminates in a cluster of
- **alveoli**

Only in the alveoli does actual gas exchange takes place. There are some 300 million alveoli in two adult lungs. These provide a surface area of some 160 m^2 (almost equal to the singles area of a tennis court and 80 times the area of our skin!).

Breathing

In mammals, the diaphragm divides the body cavity into the

- **abdominal cavity**, which contains the viscera (e.g., stomach and intestines) and the
- **thoracic cavity**, which contains the heart and lungs.

The inner surface of the thoracic cavity and the outer surface of the lungs are lined with **pleural membranes** which adhere to each other. If air is introduced between them, the adhesion is broken and the natural elasticity of the lung causes it to collapse. This can occur from trauma. And it is sometimes induced deliberately to allow the lung to rest. In either case, reinflation occurs as the air is gradually absorbed by the tissues.

Because of this adhesion, any action that increases the volume of the thoracic cavity causes the lungs to expand, drawing air into them.

- During inspiration (inhaling),
  - The external intercostal muscles contract, lifting the ribs up and out.
  - The diaphragm contracts, drawing it down .
- During expiration (exhaling), these processes are reversed and the natural elasticity of the lungs returns them to their normal volume. At rest, we breath 15–18 times a minute exchanging about 500 ml of air.
- In more vigorous expiration,
  - The internal intercostal muscles draw the ribs down and inward
  - The wall of the abdomen contracts pushing the stomach and liver upward.

Under these conditions, an average adult male can flush his lungs with about 4 liters of air at each breath. This is called the **vital capacity**. Even with maximum expiration, about 1200 ml of **residual air** remain.

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