This article, the third in a four-part series on the respiratory system, looks at the lungs, pleura and respiratory defence mechanisms.

The lungs
The lungs are cone-shaped organs that sit in the chest cavity, protected by the ribs. The apex of each is under the clavicle or collarbone, and the broad base rests on the muscular diaphragm. Each lung is divided into lobes by fissures – the right lung into three lobes and the left into two (Fig 1).

The lungs are made up mainly of millions of alveoli and consist mostly of spaces filled with air. This makes them soft and spongy in appearance and despite their size relatively light. The remainder of the lungs is made up of pulmonary connective tissue, much of which is elastic (McGeown, 2002).

Gaseous exchange takes place inside the lungs in an environment that is warm, moist and protected. The outer surfaces of the lungs are covered with a membrane called the pleura.

The pleura
The pleural membrane is thin, moist, slippery and has two layers. The outer, or parietal, pleura lines the inside of the rib cage and the diaphragm while the inner, visceral or pulmonary, layer covers the lungs. Between the two layers is the intrapleural space, which normally contains fluid secreted by the membranes. This allows the two layers to slide easily over one another as the lungs inflate and deflate during respiration.

Because it contains liquid and not gas, the space between the pleural layers is sometimes called a ‘potential’ space (McGeown, 2002). It is difficult to compress or expand liquids so the two layers of pleura normally remain tightly adherent to one another. This enables the lungs, which do not contain any skeletal muscle, to be expanded and relaxed by movements of the chest wall.

Intrapleural pressure
In their normal, relaxed, resting position the lungs are considerably smaller than the thoracic cage in which they sit. The seal of the pleura prevents the lungs from separating from the rib cage but the natural tendency of the thorax to spring out and the lungs to collapse produces forces pulling in opposite directions. This produces a negative pressure (relative to atmospheric pressure) inside the intrapleural space of about 0.5kPa (5cmH₂O). During inspiration this pressure becomes increasingly negative.

Pleurisy is an inflammation of the pleural membrane, which causes pain when the membranes rub together. Pleural effusion occurs when excess pleural fluid is formed through (Law and Watson, 2005):

- Increased permeability of the capillaries – for example, in inflammation;
- Increased pressure in the pulmonary capillaries – for instance, left ventricular failure;
- Obstruction of flow through the lung lymphatics – for example, tumour or infection.

If the pleural layers are ruptured, for example by a spontaneous rupture of the membrane or by a stab wound, air is sucked into the intrapleural space.
creating a real air-containing space between the lungs and chest wall – a pneumothorax. This abolishes the negative intrapleural pressure and the lung in the affected area will collapse. Gas exchange will be seriously impaired because movement of the chest wall will no longer expand the lung.

Protection of the airways
Protecting the delicate gas exchange surfaces in the lung is essential for health and the respiratory system has a number of ways of filtering incoming air:

- **Nasal hairs**: large airborne particles never enter the respiratory tract because they are trapped in the strong nasal hairs that stretch across the nares.

- **Mucus production**: the whole of the respiratory tract above the bronchioles is lined with epithelium, which secretes thick, sticky mucus. This not only waterproofs the inside of the respiratory tract and acts as a protective barrier against irritants but also traps bacteria and foreign particles that come into contact with it. Over 125ml of mucus is produced each day (Thibodeau and Patton, 2005) and forms a continuous sheet or mucus blanket that covers the tubes of the tract. The mucus is moved towards the pharynx on small hair-like structures called cilia. Unpleasant stimuli such as dust and debris, noxious vapours including cigarette smoke and allergens or pathogens generally cause a rapid increase in mucus production – a good example is the common cold.

- **Cilia**: these are minute hair-like projections of the epithelium lining of the respiratory tract (Fig 2). They beat 600–1,000 times a minute, sweeping the mucus, and any trapped particles in it, towards the throat where it is swallowed and destroyed by stomach juices. From the nose, mucus is moved backwards towards the throat but from the rest of the tract it is moved upwards – a system called the mucus escalator. Many bacteria are trapped in the mucus and are removed in this way. Cigarette smoke causes excess mucus production and paralyses the cilia and allows mucus to accumulate so that smokers have to cough to clear the secretions.

- **Sneezing**: sneezing is a protective reflex stimulated when the nasal mucosa is irritated. A series of short inspirations is followed by an explosive expiration, through the mouth, the nose or both. This explosive force carries droplets for long distances and is a common means of spreading disease.

- **Coughing**: coughing is a reflex mechanism for attempting to remove excess mucus or other irritants from the air passages beyond the nose. Receptors in the mucosal lining are activated and cause stimulation of the respiratory control centre in the medulla oblongata of the brain. The medulla regulates the special breathing pattern that characterises coughing. After an initial deep inspiration, a forced expiration is made. The glottis is closed during the initial expiration so air is trapped in the lungs. Pressure behind the glottis builds up rapidly and when it is reopened, air rushes out at a speed that may approach 500mph. This gathers up liquid matter and clears the airways. Coughing is a vital reflex to clear the airways since obstruction of even a small airway can lead to collapse of part of the lung and provide a focus for infection.

- **Phagocyte activity**: there are a large number of phagocytic cells in the epithelium that engulf debris, dust and bacteria and so help to filter the incoming air. The final line of defence of the airways is found in the alveoli, where macrophages are able to pick up carbon particles, bacteria and other debris.

- **Epithelial lining of respiratory tract**: this is an efficient air filter. Filtration in the nasal cavity removes particles larger than about 10 micrometres – slightly smaller particles are trapped as they pass through the bronchial tree and small particles of 1-5 micrometres in diameter are trapped in the mucus of the respiratory bronchioles or in alveolar fluid where they are engulfed by macrophages. The mucus escalator, and the coughing and sneezing reflexes clear the debris from the system.

**FIG 2. THE CILIA OF THE EPITHELIUM LINING THE RESPIRATORY TRACT**

Mucus

Cilia

Epithelial cells

**REFERENCES**

