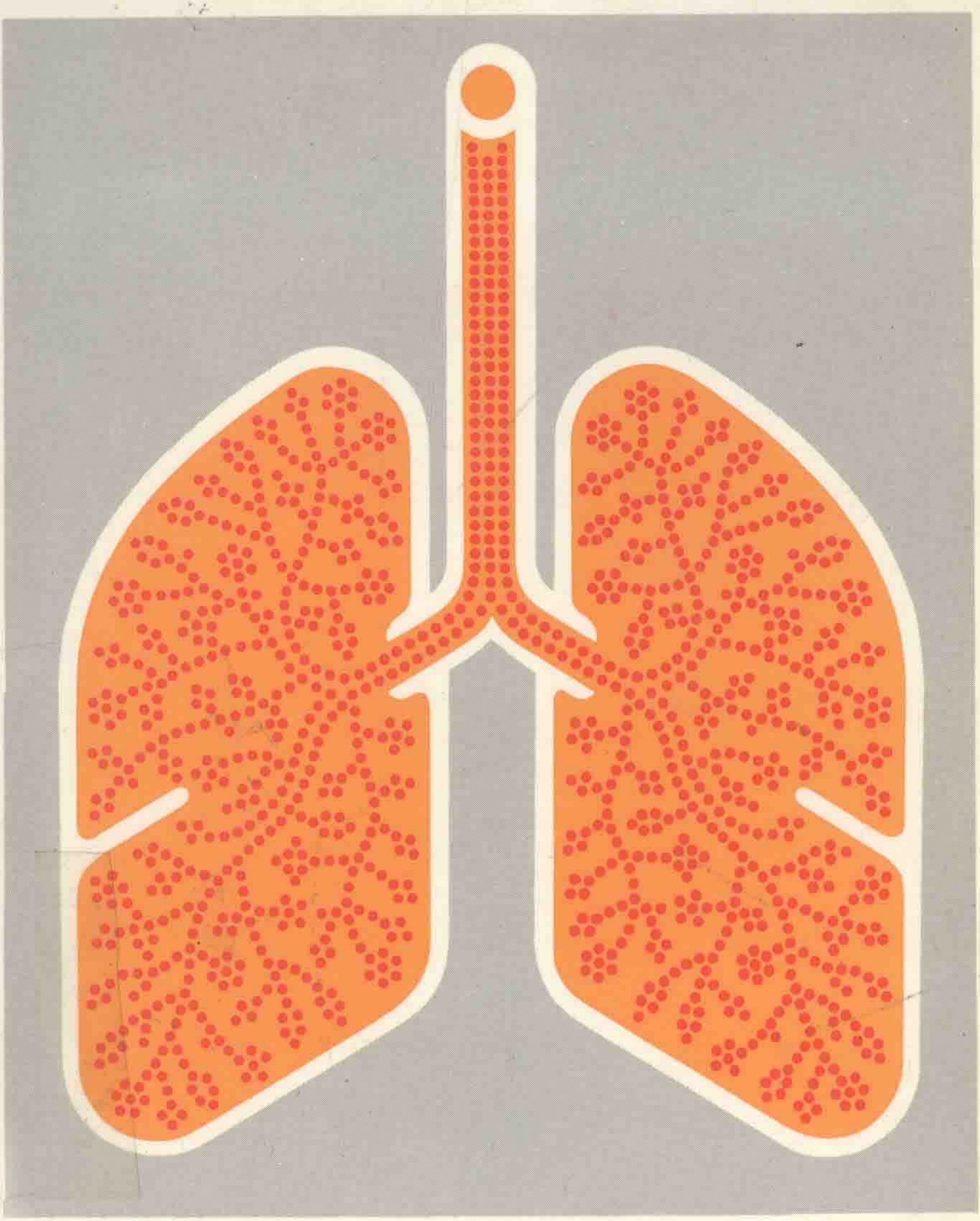
The Respiratory System

SECOND EDITION

R. Grenville-Mathers



Churchill Livingstone

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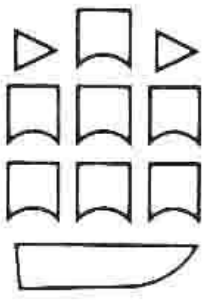

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Preface

Respiration is vital to man's survival. Indeed, there are only two ways of dying – by the cessation of breathing or by cardiac arrest.

Diseases of the respiratory system are, therefore, very important and comprise about 25 per cent of medical practice today. In winter, outbreaks of respiratory disease fill the medical wards of our hospitals and even encroach on the surgical divisions.

Many of these diseases are preventable, but knowledge of the measures necessary is not widely disseminated. So, in the preparation of this book, we have endeavoured to present the causes, nursing care and treatment of the more common respiratory diseases for the benefit of nursing staff coming in contact with such cases.

The patient benefits if the attending staff appreciate the reasons why certain procedures are used, and this requires some knowledge of the underlying theory. I hope I have presented the necessary information in a simple, informative and interesting manner.

I particularly wish to thank my various Ward Sisters and a number of Tutors who have helped me through discussions of the problems encountered by nurses.

Invaluable help and a wealth of experienced advice has also been rendered to me by the publishers, to whom I am most grateful.

1983

R.G-M.

To ANWAR

My *'Light of Lights'*

Contents

One

The thorax

The respiratory system

Respiration is the act of breathing. We breathe in air through the nose and mouth, it then passes through the *pharynx* (the space at the back of the mouth), the *larynx* (or voicebox) situated at the front of the neck, through the *trachea* (or windpipe), and into the lungs. The upper part of the trunk which contains the lungs is called the *thorax* (Fig. 1.1).

The oxygen contained in the air we breathe is essential to life; without it we die in a matter of minutes. The cells of our bodies need oxygen to burn food in order to provide them with the energy

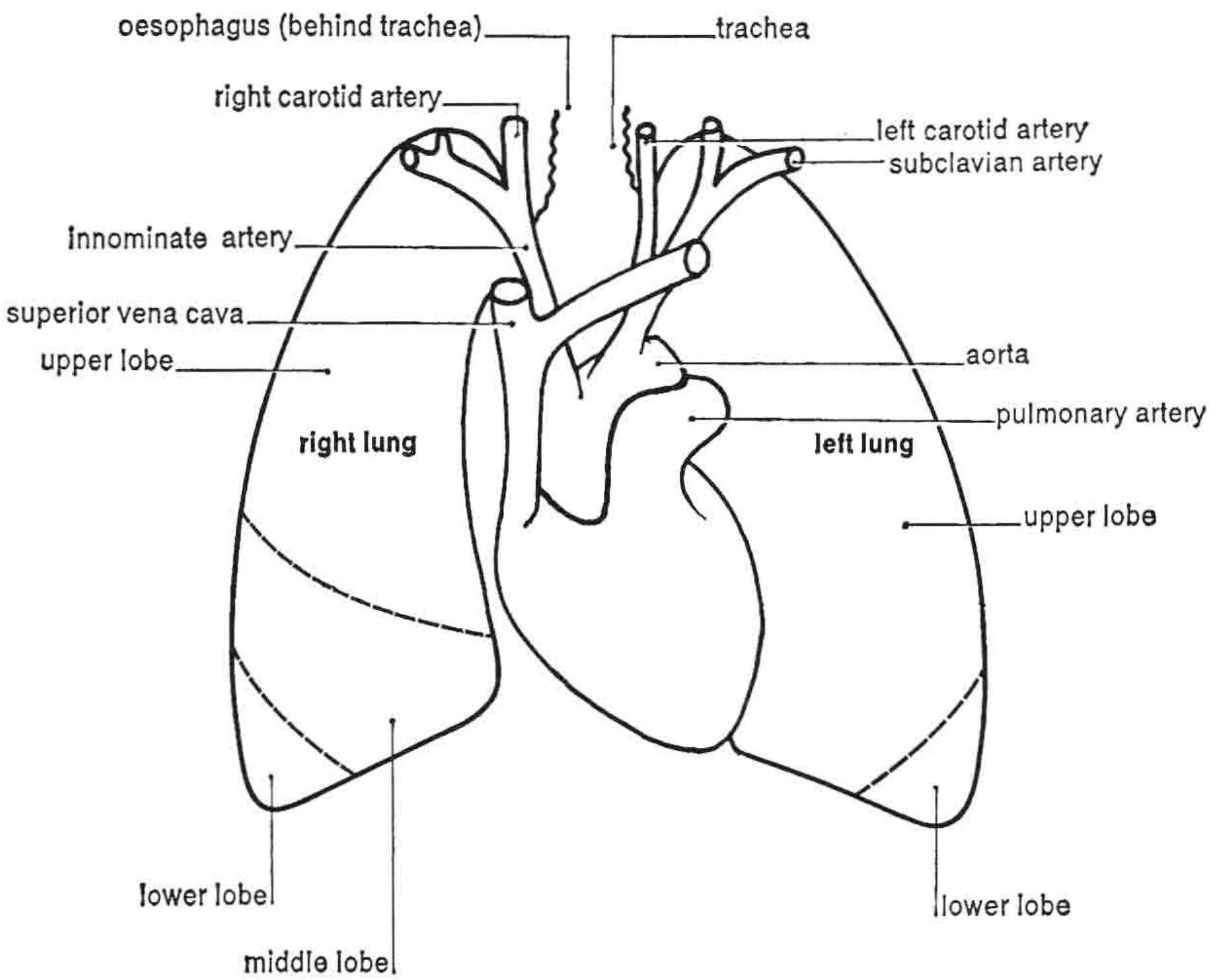

Fig. 1.1 The thorax

to carry out their functions. Another gas, carbon dioxide, is produced as a result of this process. It is poisonous in high concentrations, and has to be removed from the body.

Man needs large amounts of oxygen to stay alive, and one of the functions of the blood stream is to carry oxygen to the cells and to bring back carbon dioxide (Fig. 1.2). The lungs provide the mechanism by which these gases are exchanged. Each lung consists of a large membrane folded many times in order to get a large surface area into a relatively small volume. The blood is on one side of this membrane and the oxygen in the lungs is on the other. Because the pressure of oxygen is lower in the blood than it is on the other side of the membrane, oxygen passes through the membrane and into the blood, where it dissolves. Carbon dioxide passes through the membrane from the blood into the air in the lungs because the pressure of the carbon dioxide is greater in the blood than in the air.

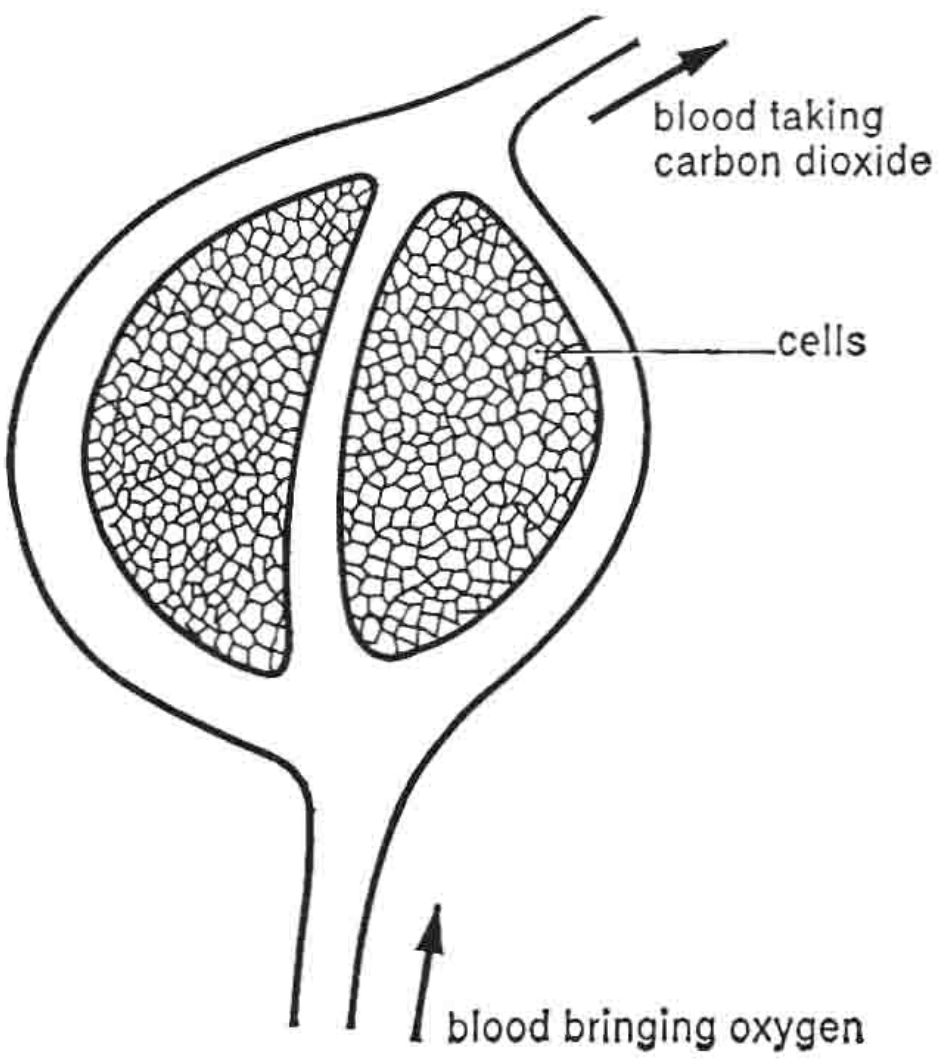

Fig. 1.2 The vascular system

The trachea and bronchi

The air reaches the lungs through a series of conducting tubes. After the air has been filtered, warmed and saturated with water vapour by the nose, it passes through the pharynx, the larynx and down the trachea. This tube is kept rigidly open by rings of cartilage so that the air can always pass freely down it. These rings are incomplete at the back where the *oesophagus* (gullet) lies against the trachea. At its lower end, the trachea divides into two smaller

tubes, also ringed with cartilage, called the left and right main *bronchi*. The angle between the two main bronchi is called the *carina*. The right bronchus is shorter and more vertical than the left, so inhaled foreign bodies usually drop into this side. It divides into three branches, to the upper, middle and lower lobes of the right lung, while the left bronchus divides into only two, to the upper and lower lobes of the, slightly smaller, left lung. In these lobes, the tubes divide again and again, ending in tiny sacs called *alveoli*, where most of the gas exchange occurs. The whole arrangement is very much like a tree, the trachea forming the trunk and the bronchi forming the major boughs, which give off smaller and smaller branches (Fig. 1.3).

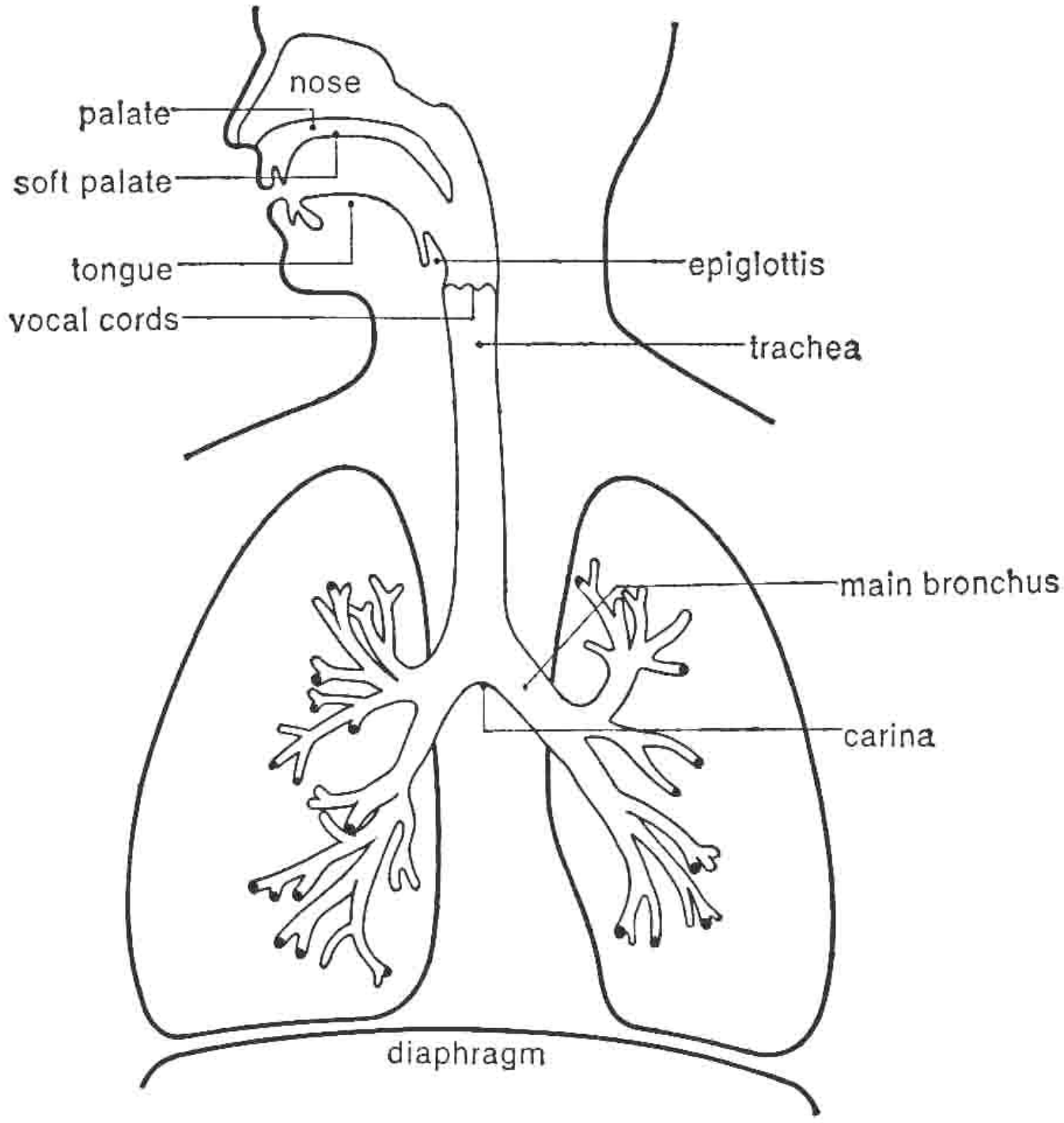

Fig. 1.3 The trachea and bronchi

Development of the lungs

The lungs did not originate in the thorax (the upper part of the trunk). In the foetus, a small ridge develops in the floor of the gut, and this is eventually cut off from the oesophagus, forming a separate tube leading into the pharynx just in front of the oesophagus. The upper part of this tube develops into the larynx and the trachea and the lower part into the lung bud, which then divides to form the left and right lungs (Fig. 1.4).

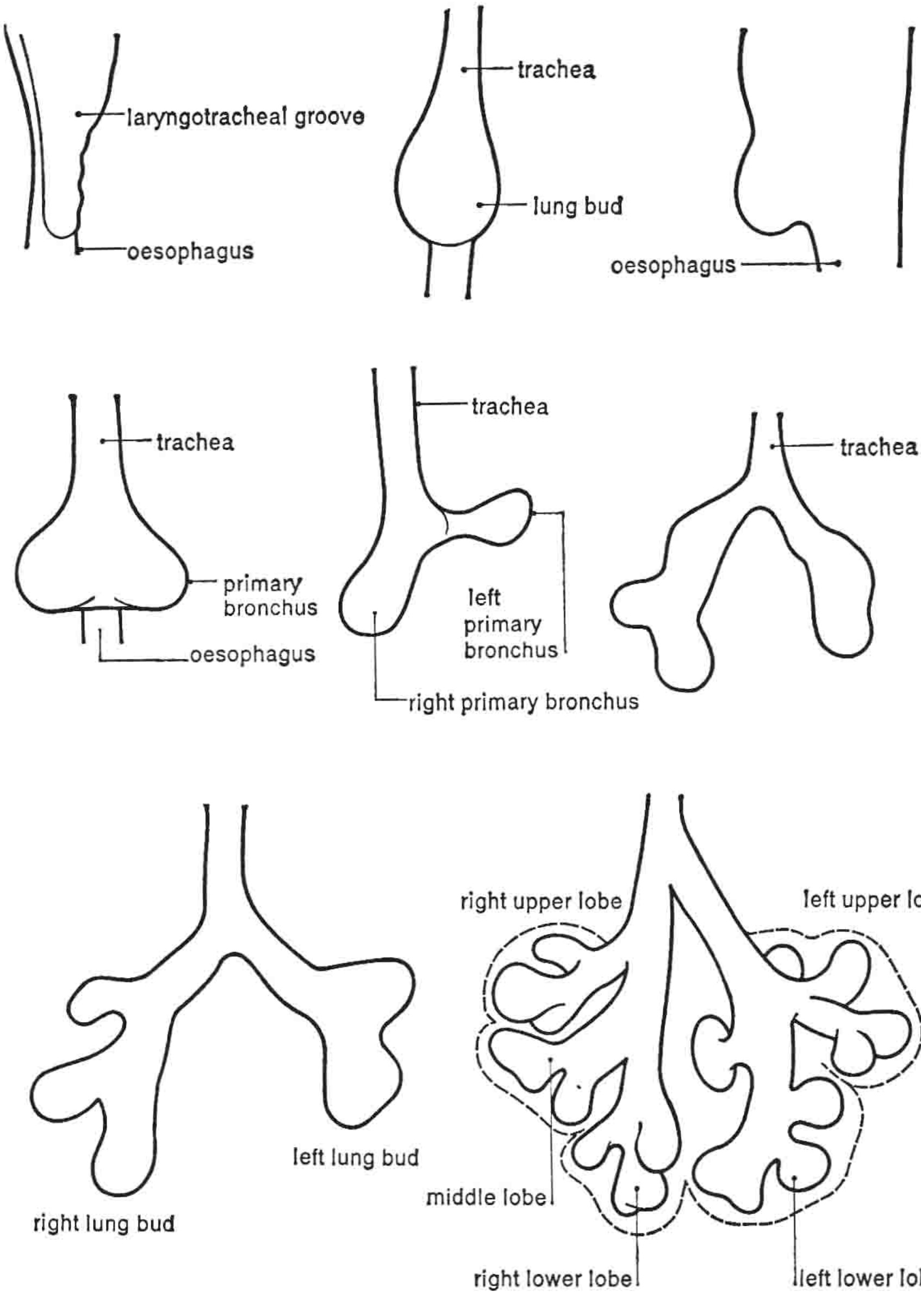

Fig. 1.4 Development of the trachea, bronchi and lungs

The tracheal tube gradually lengthens and becomes lined with a coating of cells called *columnar epithelium*. These cells (Fig. 1.5) have small hair-like projections (*cilia*) which trap any dirt particles reaching the trachea. The cilia are covered with *mucus*, which is produced by the bronchial glands and, as the cilia move (Fig. 1.6), the mucus sticks to the dirt particles, forming blebs which can be coughed up.

The lung buds give off bronchial buds soon after they are formed

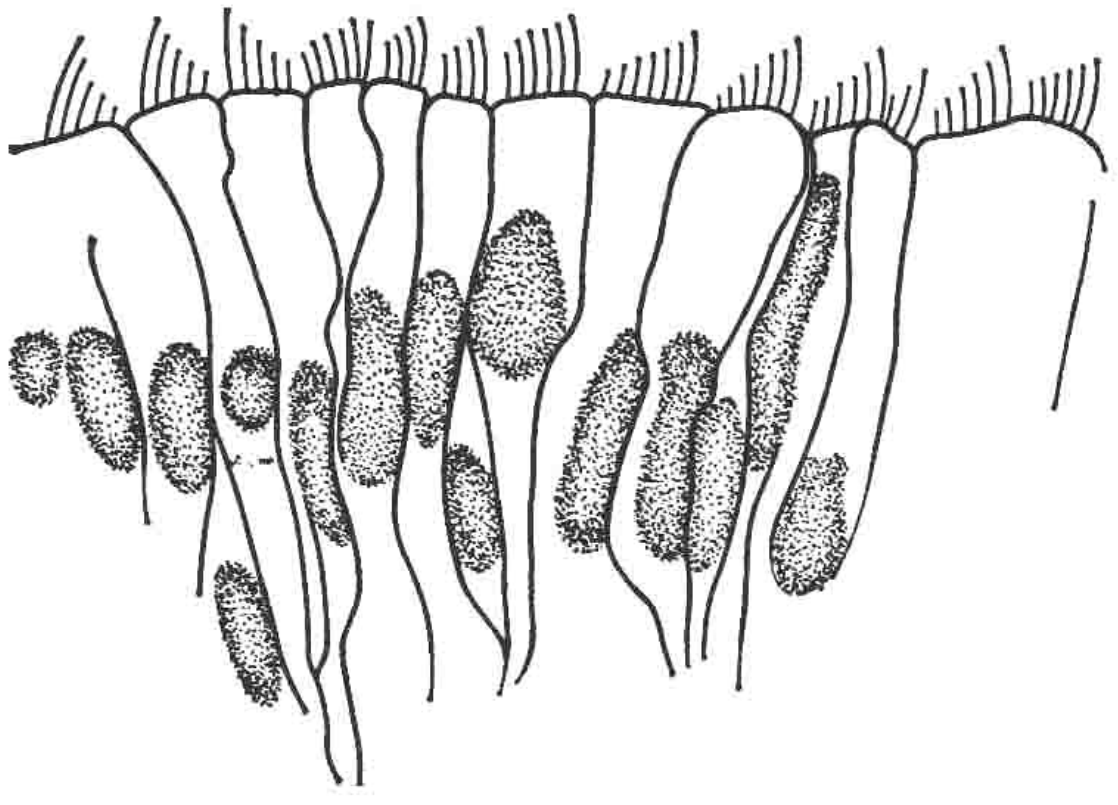

Fig. 1.5 Ciliated cells

Fig. 1.6 Movement of cilia

and these will develop into the bronchial tree, the smallest branches terminating in the alveoli. The walls of these tiny sacs are pressed together during foetal life, and they only open up and start functioning at birth. When the baby is born, the bronchial buds have already divided eighteen times, and this branching process goes on until twenty-four divisions have occurred. This usually takes until middle childhood.

Until the baby is born, the lungs are relatively small, since they are not used. When the baby starts breathing, the lungs gradually expand to fill the lung cavity. (This is significant from the legal point of view, as it shows whether or not a newborn baby has breathed.) The lungs will have fully expanded by the fourth day of life, and then the lung margins will be rounded and the lung tissue will be light and spongy.

The thoracic cage

The *thoracic cage* protects the lungs, the heart and the great vessels. It is formed by the breast bone (*sternum*) anteriorly, by twelve thoracic vertebrae posteriorly, and by twelve ribs on each side. Above it are the muscles and structures in the root of the neck. Below it is the *diaphragm*, a sheet of muscle separating the thorax from the abdomen.

The sternum (Fig. 1.7) is made up of three parts, an upper sec-

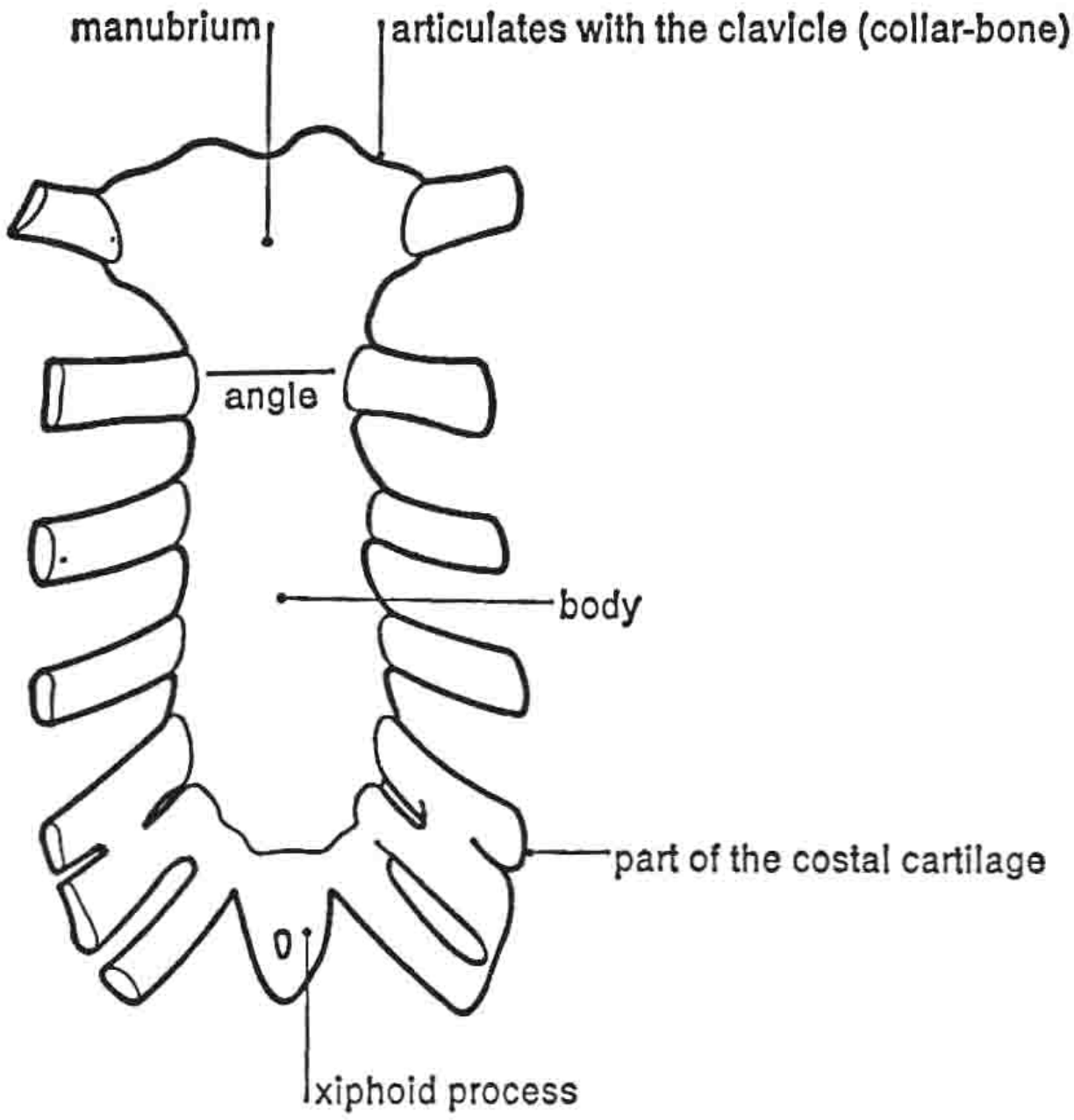

Fig. 1.7 The sternum

tion called the *manubrium*, a middle section called the *body* and a lower section called the *xiphoid process*.

Each of the twelve thoracic vertebrae or *dorsal vertebrae* (Fig. 1.8) has a small depression at the side for the head of the rib and a similar depression on the transverse process for the rib tubercle. The body of each vertebra is heart-shaped with a circular hole (the *vertebral foramen*) through which the spinal cord passes. The spine and the transverse processes on either side provide the attachments for the powerful back muscles.

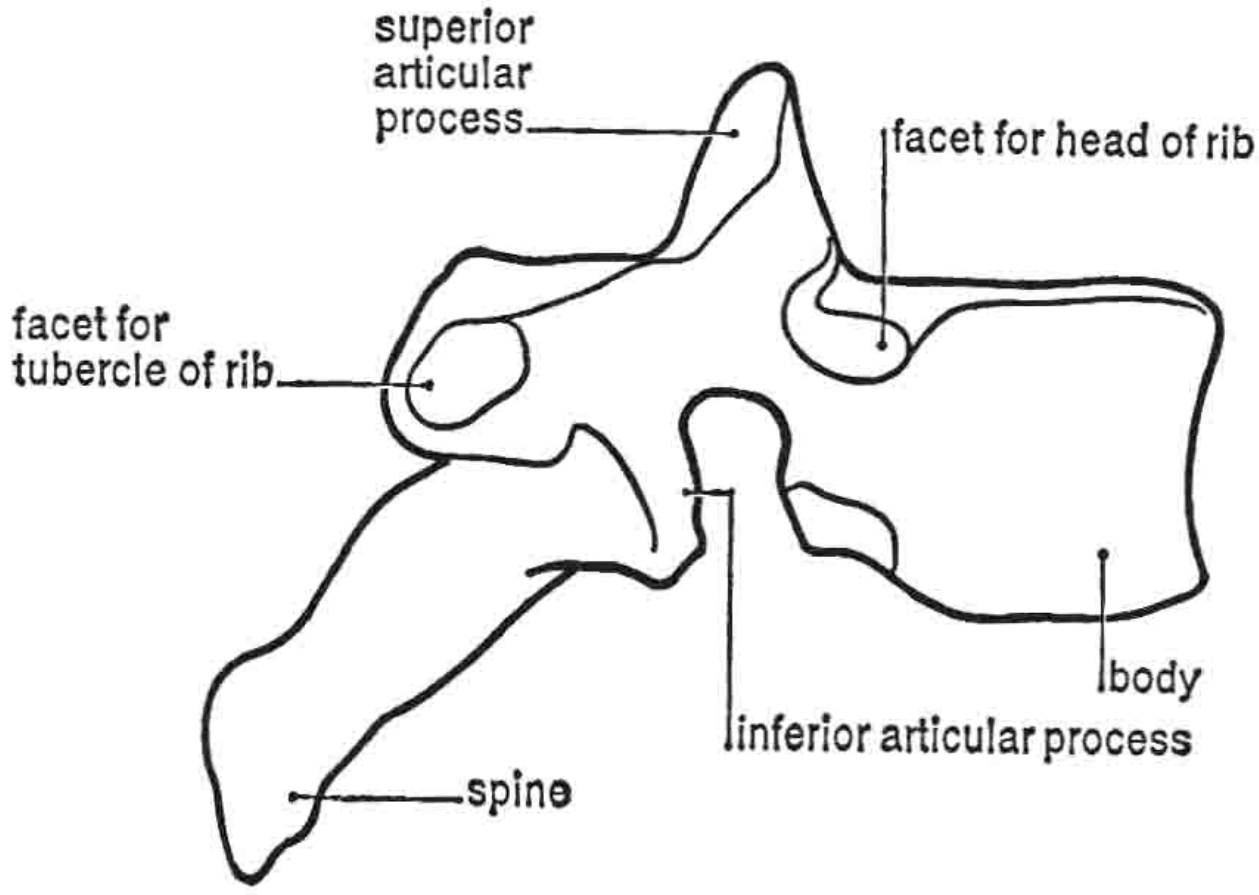

Fig. 1.8 Thoracic vertebra

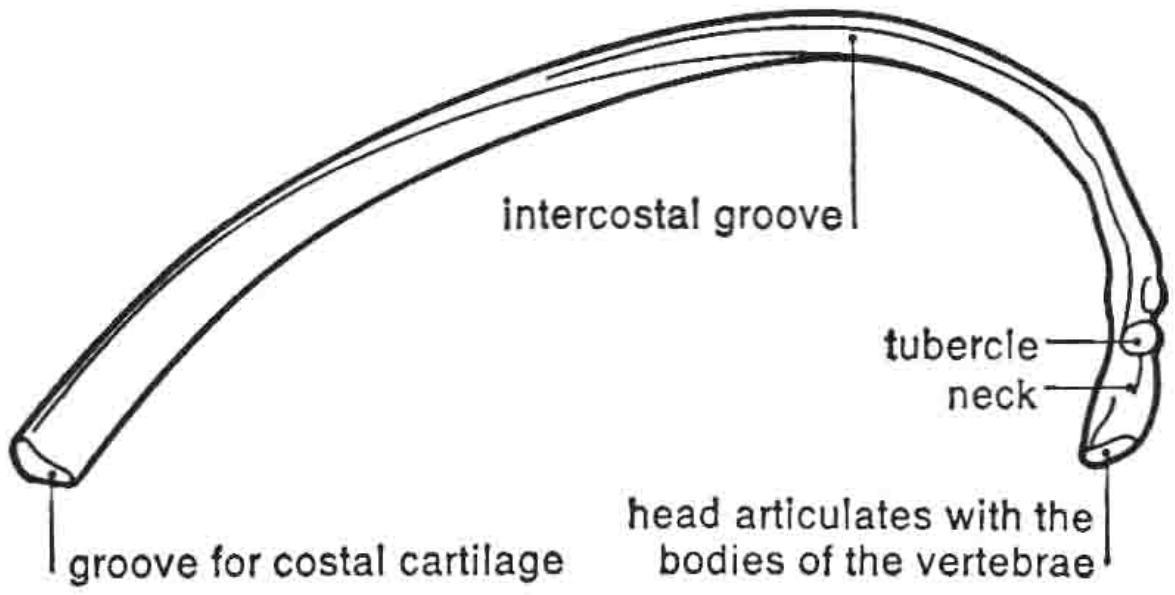

Fig. 1.9 A rib

The ribs themselves are curved, flat bones composed of a head, a neck, a tubercle and a shaft (Fig. 1.9). The upper seven pairs of ribs ('true ribs') are attached directly to the sternum by costal cartilages. The lower five pairs are called 'false' ribs. The first three pairs of these have their costal cartilages attached to those of the ribs above, and the remaining two pairs (the 'floating ribs') have no costal cartilages (Fig. 1.10). At the back, the head of the rib fits into the depression on the side of the thoracic vertebra, and the tubercle fits into the depression in the transverse process.

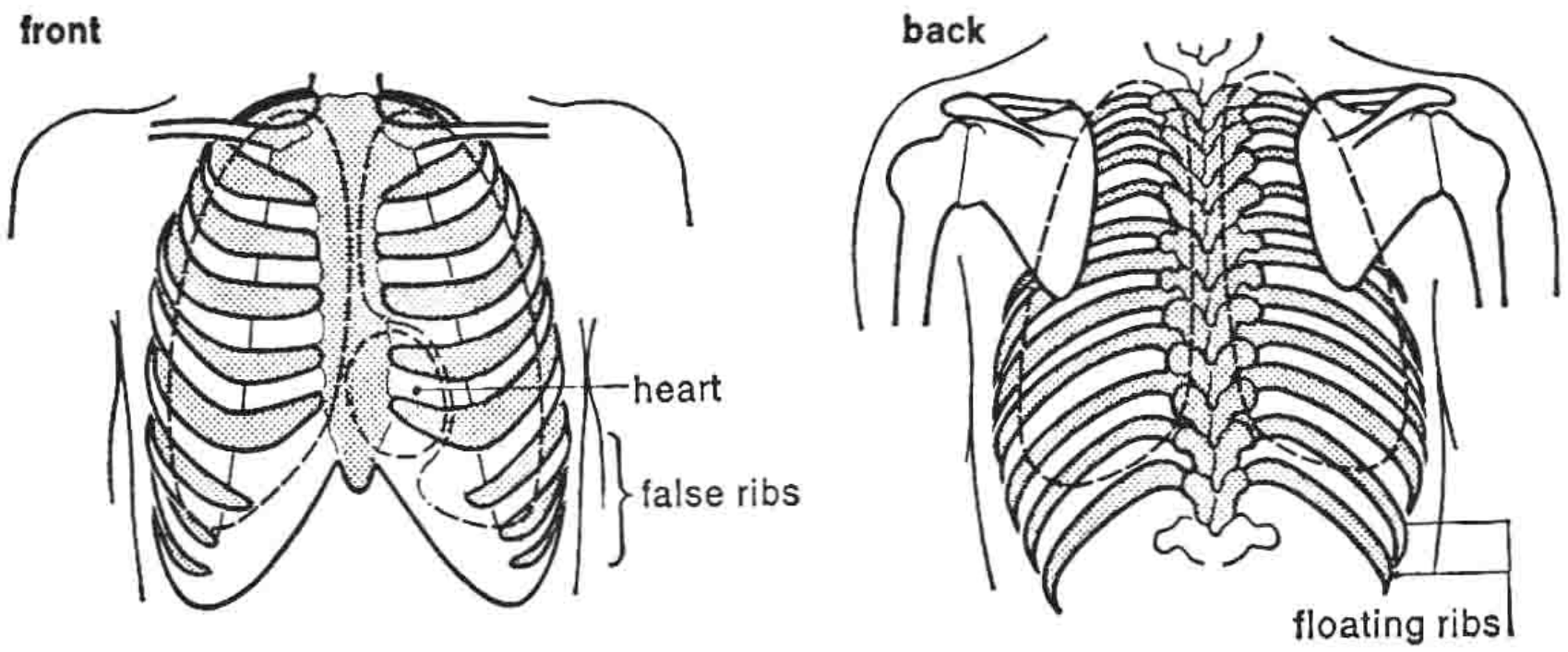

Fig. 1.10 The ribs

Occasionally an extra rib may develop in the neck, usually projecting from the seventh cervical vertebra. This *cervical rib* can cause pain and numbness in the arm because it may compress the nerves which supply the arm. These nerves arise in the neck and pass over the first rib, where the cervical rib can press on them.

Between each pair of ribs are the external and internal *intercostal muscles*. These, together with the diaphragm, are the muscles chiefly responsible for the movements involved in respiration. The external intercostal muscles arise from the lower border of a rib and pass to the upper border of the one below. The fibres of these mus-

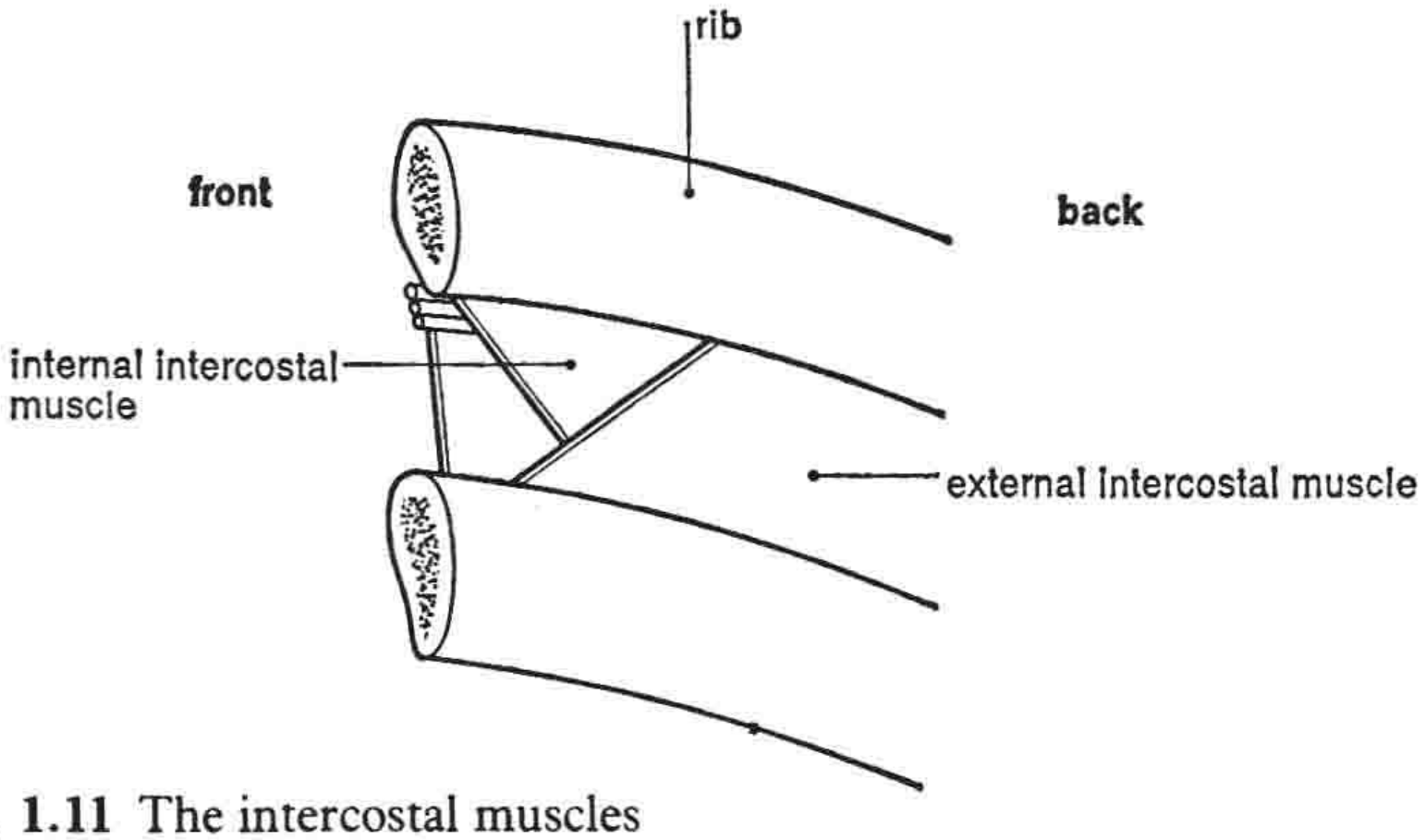

Fig. 1.11 The intercostal muscles

cles run obliquely forward (Fig. 1.11). The internal intercostal muscles lie inside the external intercostal muscles with their fibres running from front to back.

Along the lower border of each rib is a groove containing the intercostal artery, which supplies blood to the muscles in that rib space. The intercostal arteries are branches of the descending part of the thoracic aorta. Accompanying the artery are a vein and the intercostal nerve, which innervates the intercostal muscles. The blood vessels and nerve in this groove are thus protected from damage. Any needle inserted into the chest should go as close as possible to the bottom of the rib space to avoid damage to the blood vessels or to the nerve.

When the rib cage is relaxed, the head of the rib is higher than that of the top of the rib above. When the intercostal muscles contract they pull the ribs upwards and outwards (like the handle of a bucket), increasing the circumference of the thorax (Fig. 1.12).

The diaphragm

The diaphragm is a sheet of muscle separating the thorax from the abdomen. It is shaped like a dome and arises from the lumbar vertebrae, from the back of the lower part of the sternum and from the inner side of the lower six ribs. Its muscle fibres converge on a flat sheet of dense fibrous tissue known as the *central tendon* (Fig. 1.13). When these muscles contract, the central tendon is pulled downwards towards the abdomen. This lowers the pressure in the thorax and draws air into the lungs. When the muscles relax, the diaphragm rises again, pushing air out of the lungs (see Fig. 1.12).

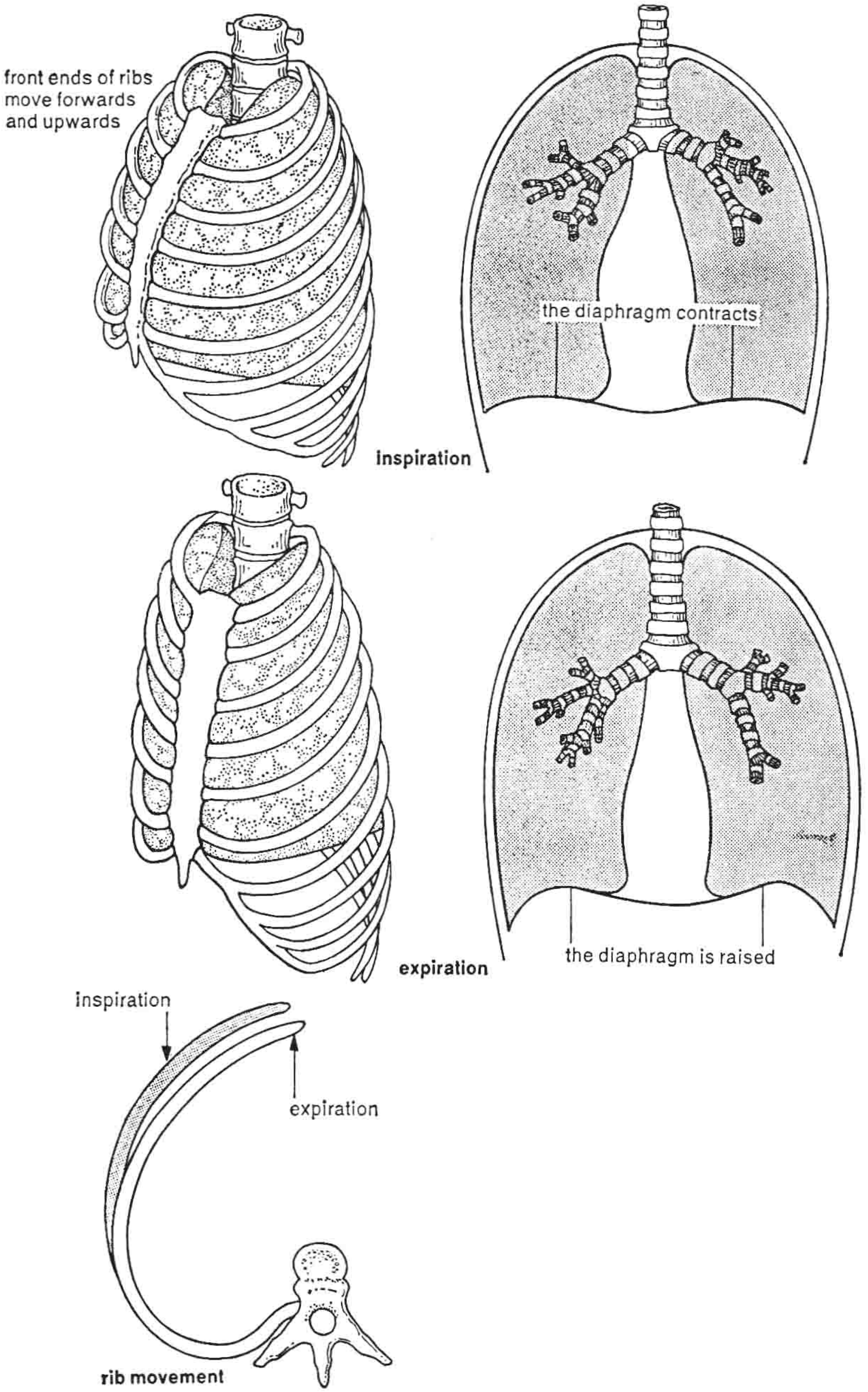

Fig. 1.12 Respiration

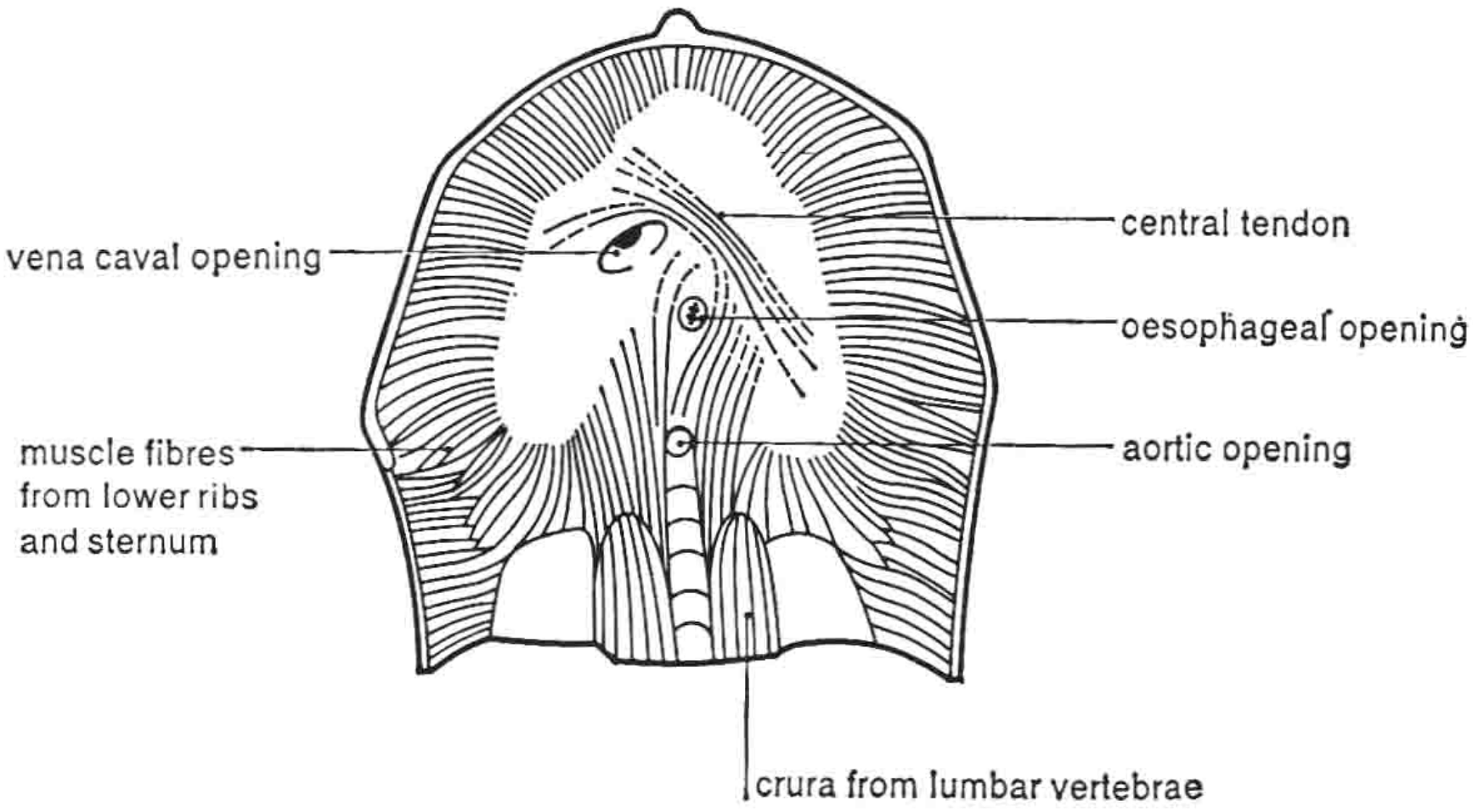

Fig. 1.13 The diaphragm

The nerve impulses which make the diaphragm contract flow through the *phrenic nerves* on either side of the diaphragm. These arise in the third, fourth and fifth cervical segments of the spinal cord and pass down the inner side of each lung to reach the diaphragm. Their action is controlled by the respiratory centre of the brain, which is in the medulla.

When breathing is difficult, the *accessory muscles* come into action (these normally move the head, arms and shoulder blades). When the arms and head are held steady, these muscles raise the front of the chest, increasing the volume inside. They consist of the *pectoralis major* muscle, which lies in the front wall of the chest, the *serratus anterior* muscle, which runs round the lateral wall of the chest, and the *sterno-mastoid* muscle, which passes from the back of the skull to the collar-bone. The abdominal muscles can also help breathing difficulty by pushing the diaphragm upwards when breathing out. In practice, most women use mainly the intercostal muscles (thoracic breathing) and men the diaphragm (abdominal breathing).

The lungs

The lungs, the organs of respiration, are situated on each side of the chest, separated by the heart, the aorta and the oesophagus. They are conical in shape, the apex rising into the root of the neck about two centimetres above the midpoint of the collar-bone (*clavicle*), the base resting on the diaphragm. The right lung is divided into three lobes, the upper, middle and lower lobes, and the left

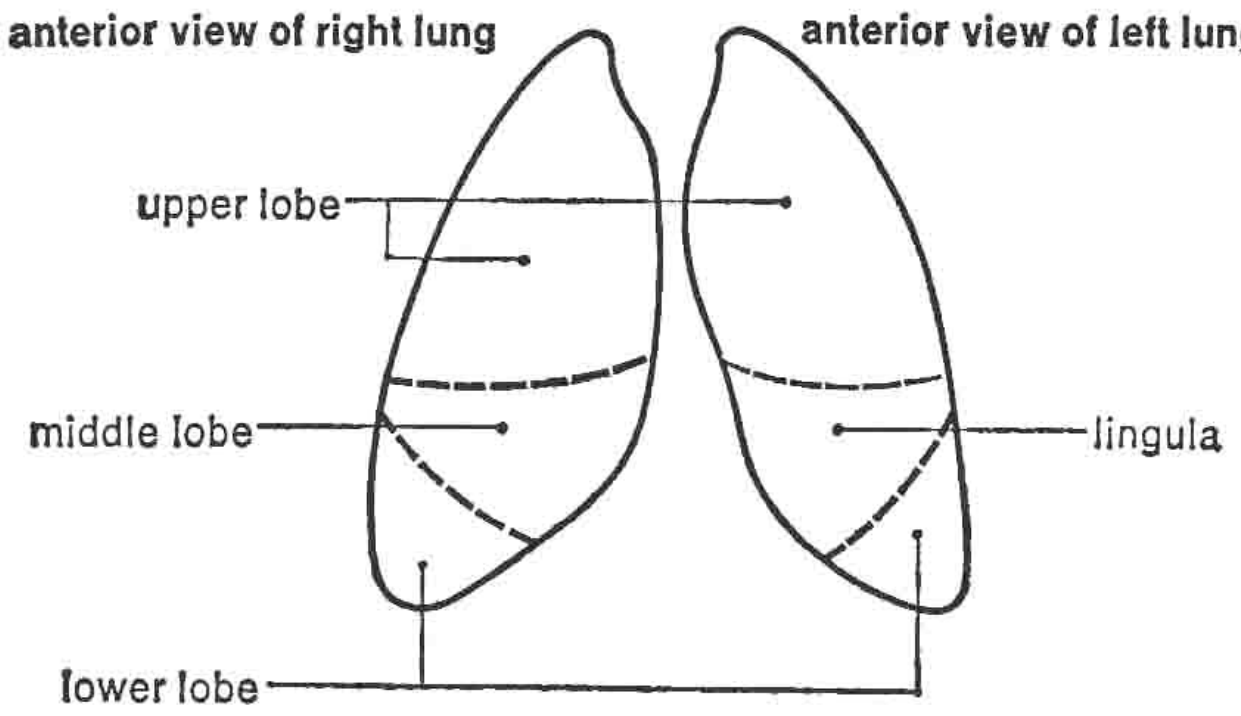

Fig. 1.14 The lungs

into two, the upper and lower lobes. The part of the left upper lobe that corresponds to the right middle lobe is known as the *lingula* (Fig. 1.14).

The root of the lung is on the medial surface and here the air tubes, the pulmonary artery and veins, the bronchial arteries and veins, and the pulmonary nerves all enter it. Each lobe is divided into a number of lobules consisting of a bronchial tube, air cells, blood vessels, lymphatics and nerves, all held together by connective tissue. The bronchial tubes end in a number of smaller tubes or bronchioles. Each of these terminates in an expansion called the *infundibulum*, off which branch the alveoli. These minute, pouch-like structures are arranged like a bunch of grapes, the bronchiole being the stem (Fig. 1.15). The many alveoli allow the large surface area of the lung to be stored in a compact space.

The very thin walls of the alveoli are made up of a single layer of cells (*pavement epithelium*). Each alveolus is surrounded by abundant blood capillaries (supplied with blood by the pulmonary arteries), so that there can be an easy exchange of oxygen and carbon dioxide. Oxygen is absorbed into the blood and taken up by the pigment *haemoglobin* in the red corpuscles. At the same time, the blood gives up the carbon dioxide which has been absorbed as waste matter from the cells. Water, too, passes out of the blood into the lungs, and is exhaled in the breath together with the carbon dioxide.

Each lung is surrounded by a continuous membrane, the *pleura*. The inner layer (the *visceral pleura*) closely covers the lung, passing into the fissures and separating the lobes. This membrane doubles back on itself at the root of the lung and forms the *parietal pleura* which covers the interior of the chest wall, the upper surface of the diaphragm, and the mediastinum. There is a space (the *pleural space*) between the two layers of pleura, and the pressure within