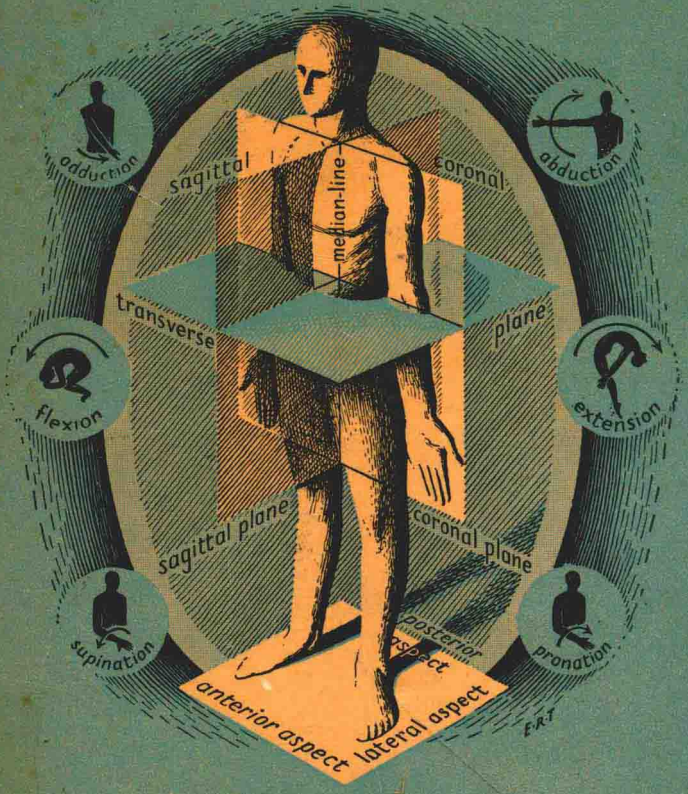
A MANUAL OF HUMAN
ANATOMY
I
THORAX & UPPER LIMB



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E. & S. LIVINGSTONE LTD., EDINBURGH AND LONDON

A MANUAL OF HUMAN ANATOMY

VOLUME I

THORAX & UPPER LIMB

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1956

PREFACE

THE purpose of these Manuals is to give the student of human anatomy a method of dissecting the body and to guide him as to the extent of the knowledge expected of him in the second medical examination. An attempt has been made to link together the structure and function of the different parts of the body, and the anatomy necessary for a future study of clinical medicine or an understanding of the development of the part is emphasised. Paragraphs indicating the functions of the parts under consideration have, where appropriate, been introduced after the dissecting instructions and topographical details. The study of the anatomy of each part can thus be undertaken with some knowledge of the functional implications and not as a mere exercise of memory. Much detail has been omitted.

A co-ordinated course is more easily organised if all the members of the class are dissecting the same part at the same time and the instructions in the Manuals are presented on this assumption. A most important part of the teaching is carried out by means of small classes on osteology and surface anatomy. For these classes we have found it useful to indicate what the students should know. The students do the work themselves and it is then checked by a demonstrator. Appropriate lists for such work are found at the end of each volume.

It has been found advantageous to begin with the dissection of the thorax. This results in an early acquaintance with the heart and lungs and with the peripheral and autonomic nervous systems, all of which receive attention in most introductory courses of physiology. From the thorax, the student proceeds to dissect the upper limb (vol. I), the head and neck (vol. II), the abdomen and pelvis (vol. III) and the lower limb (vol. IV). The descriptions and instructions in the Manuals assume that this order has been followed. Instructions for the use of the Manuals where a different order is employed are given opposite page 1. The gross and histological structure of the brain and spinal cord are described in vol. V.

Each part of the body is subdivided for convenience into smaller regions. In the limbs these regions centre around the joints and in

other parts around the larger morphological or functional units. In each region, a short introduction is followed by dissecting instructions, including a description of many of the structures being dissected. There follow paragraphs on further details and relations of the structures, and their functions.

Summaries of the cutaneous nerve supply and of the lymphatic drainage of the part dissected are found towards the end of each section of the Manual.

In the early stages of the planning and writing of these Manuals, Dr. W. A. Fell, now of Addenbrooke's Hospital, Cambridge, and Dr. D. H. L. Evans of University College, London, contributed to the work and much helpful criticism has been received from other colleagues and students.

The illustrations were produced by Miss E. R. Turlington and Miss J. de Vere, largely from specimens and drawings in the Anatomy Department at University College, London. As the main object of the pictures is to illustrate the text, all unnecessary complicating details have been omitted and the salient features emphasised by the use of colour.

Our thanks are also due to Miss A. Baxter and Miss M. Lynn for typing the final draft of the Manuals, and Mr. Macmillan and the staff of E. & S. Livingstone for the production and publication of the Manuals.

THE AUTHORS.

London,
February, 1956.

NOTE

In Departments where different groups of students dissect the various parts of the body at the same time, some re-arrangement of the order of dissection is required. Dissectors of the upper limb should work in the first stages with those dissecting the thorax (Volume I, pages 1 to 7) and then proceed to the rest of the dissection of the upper limb (Volume I, Chapter IX). The dissectors of the lower limb begin with the front of the thigh (Volume IV, Chapter IV). Dissectors of the abdomen and the head and neck can begin with the appropriate Volumes.

If dissection is begun with the body on its face, those dissecting head and neck should work with the dissectors of the upper limb for the dissection of the superficial muscles of the back (Volume I, Chapter XII), and then dissect the suboccipital triangle, etc. (Volume II, Chapter II). Dissectors of the thorax and abdomen wait until the body is placed on its back. The dissectors of the lower limb begin with the gluteal region (Volume IV, Chapter III).

CONTENTS

THORAX

CHAPTER I

GENERAL INTRODUCTION

THE arrangement of the vertebral column, ribs and thoracic musculature of man is based on the segmental plan inherited by all mammals from their fish-like ancestry and modified first for quadrupedal and then for bipedal locomotion. In the upright position adopted by man the vertebral column is used as a pillar transmitting the weight of the body through the pelvic girdle to the lower limbs.

The skeleton of the thorax (the **thoracic cage**) is made up of twelve thoracic vertebrae, bearing on each side twelve ribs, ten of which are attached directly or indirectly by costal cartilages to the **sternum** or breast bone. This skeletal framework surrounds a cavity which is limited below by the diaphragm. Above, the **thoracic inlet** is formed by the 1st ribs, manubrium sterni and 1st thoracic vertebra. The thoracic cavity contains the heart and lungs, along with the aorta and its branches, the superior vena cava and its tributaries, the inferior vena cava, the oesophagus and other structures (nerves, lymph nodes, and the thymus gland). The diaphragm and the muscles in the thoracic walls enable the thorax to be used as a bellows, producing ventilation of the lungs.

The weight of the arm is carried by a complex system of muscles and bones. Some of these muscles are attached to the thorax, which therefore plays a part in supporting the weight of the arms. In quadrupeds, where weight is transmitted to the ground through the arms, or in brachiating animals like the great apes who hang by their arms, the mechanical functions of the thorax are different from those in man.

The lower part of the thoracic wall also plays an important part in supporting the abdominal viscera. These viscera are kept in position by the tone of the abdominal muscles, which are attached to the lower ribs. The ribs act as brackets attached to the vertebral column.

The thorax can therefore be said:

1. to act as a respiratory bellows;

2. to contain the heart, lungs and large blood vessels;
3. to assist in supporting the weight of the arms;
4. to assist in supporting the abdominal viscera;
5. to transmit the oesophagus, nerves and other structures.

ORIENTATION

To help in the description of a structure or a region, certain terms are used and they have an agreed interpretation. The **anatomical position** is one in which the person stands upright, feet together, eyes looking forward, arms straight along the sides with the palms of the hands directed forwards. The front of the body is called the **anterior** surface and the back is called the **posterior** surface (see cover drawing). The terms **ventral** and **dorsal** may be used for the front and back respectively. Higher structures are **superior** and lower structures are **inferior. Median** structures are found in the midline of the body (or of a limb) and the terms **medial** (nearer to) and **lateral** (further from) are relative to the midline.

A **sagittal** plane passes vertically anteroposteriorly through the body. Forward movements at joints in this plane are called **flexion** and backward movements are called **extension.** A vertical plane at right angles to the sagittal is called a **coronal** plane. Movements of joints in this plane are **abduction,** away from, and **adduction,** towards, the midline. At certain joints, **rotation** also occurs around a longitudinal axis.

THE BONY FRAMEWORK OF THE THORAX

Examine the articulated skeleton and note the construction of the thorax. Behind is the thoracic part of the vertebral column. In front is the sternum. These two semi-rigid pillars are connected by ten pairs of ribs and costal cartilages.

Two lower pairs of free ribs articulate only with the vertebral column.

The thoracic part of the vertebral column

The thoracic part of the vertebral column consists of twelve thoracic vertebrae, separated by intervertebral discs, which account for a quarter to a third of the length of the column. A typical

thoracic vertebra has a **body** in front, through which weight is largely transmitted. Behind the body is the **vertebral arch,** enclosing the **vertebral foramen,** in which lie the spinal cord and its membranes. From the back of the vertebral arch, the **spinous process** projects backwards and downwards in the midline. Projecting laterally from the vertebral arch are two **transverse processes.**

The sternum

The sternum has three parts from above downwards, the **manubrium,** the **body** and the **xiphoid process.** The body and the manubrium meet at the **sternal angle,** a palpable landmark at the level of the 2nd costosternal joint.

On the manubrium, identify the **suprasternal notch** on the upper border and the articulations for the **clavicles** (collar bones) and 1st costal cartilages.

The ribs and costal cartilages

A typical rib articulates behind by its **head** with the bodies of two thoracic vertebrae, and more laterally by its **tubercle** with a transverse process. Beyond this latter articulation the flattened shaft continues laterally to the **angle** and then passes forwards round the thoracic cavity. On the internal aspect of the lower border of the shaft is the **costal groove.**

Anteriorly the rib is continuous at a costochondral junction with a flexible costal cartilage, which articulates with the sternum. Below, the costal cartilages of the lower ribs turn upwards and forwards to form the costal margin, which marks part of the boundary between the thoracic and abdominal walls.

Correlate the findings on the articulated skeleton with what can be seen and felt in the cadaver and living person.

The topographical divisions of the thorax

The contents of the thorax fall naturally into three divisions; the lungs and their coverings are on each side, and the third is the space between them (the **mediastinum**) containing the heart, large vessels, oesophagus and nerves.

The mediastinum is often subdivided for descriptive purposes into superior and inferior parts and the latter further subdivided into anterior, middle and posterior parts.

CHAPTER II

THE CHEST WALL

INTRODUCTION

THE framework of the chest wall is concerned with respiration and also with providing a support for the shoulder girdle. Movement of the ribs and of the diaphragm changes the capacity of the chest so that air is inhaled or exhaled.

On the cadaver identify the following bony points: the midpoint of the clavicle, the suprasternal notch, the xiphoid process, the sternal angle, the 2nd to the 10th ribs and costal cartilages, the costal margin. Between the ribs feel the intercostal spaces; these are numbered according to the number of the rib forming the upper boundary. The hollow between the arm and the thorax is called the **axilla.**

DISSECTION

Make incisions through the skin as follows:

1. from the suprasternal notch to the tip of the xiphoid process,
2. from the suprasternal notch along the clavicle to its midpoint,
3. from the xiphoid process along the costal margin to the midaxillary line,
4. round the nipple, 3 cm in radius.

The superficial structures

With forceps take hold of one corner of the flap of skin thus marked out and dissect it away from the underlying tissue. In this manner the flap should be reflected laterally and backwards as far as the midpoint of the clavicle and as far as the lowest point of the costal margin. The skin around the nipple should not be dissected off. After removing the skin, the underlying subcutaneous tissue, called the **superficial fascia,** is exposed; it often contains much fat. Though it appears in the cadaver as a firm and tough layer, in the living body the fascia is loose and not firmly attached to the skin, and at body temperature the fat globules are fluid. The superficial fascia thus allows movement of the skin on

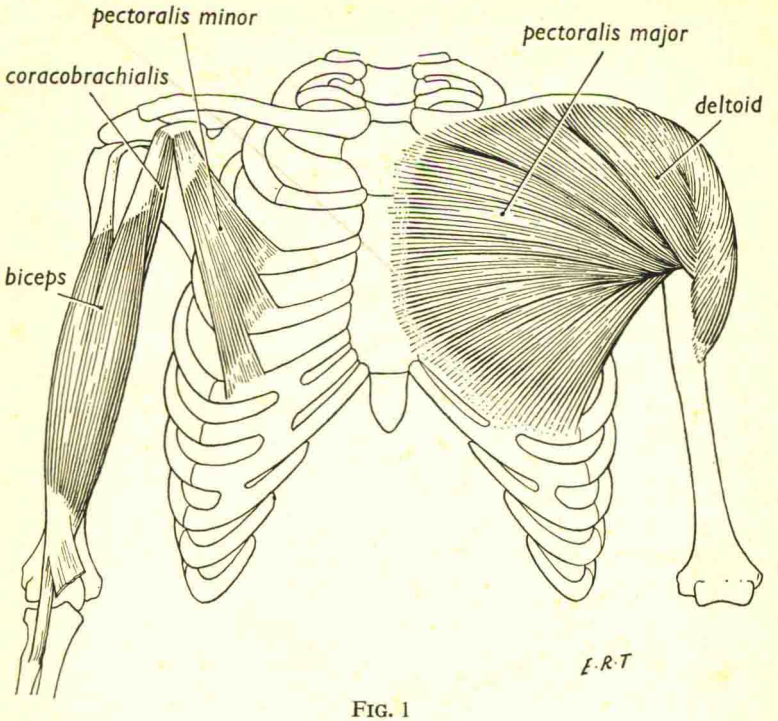

FIG. 1
On the right side, pectoralis major and deltoid muscles have been removed to expose the attachments of pectoralis minor, coracobrachialis and biceps.

the underlying structures. In certain situations such as the palm of the hand and the sole of the foot where such movement would be disadvantageous, the skin is firmly attached to the deeper tissues.

The **mammary gland** lies in the superficial fascia. In the male it remains rudimentary throughout life. In the female it changes considerably with age and it increases in size during pregnancy and lactation. It is commonly the site of disease and therefore although it cannot be properly dissected even in female cadavers, its anatomy must be known in some detail (see page 16).

With a scalpel and forceps remove the exposed superficial fascia. Small blood vessels and nerves are seen entering its deep surface on their way to the skin. The underlying **deep fascia** is now exposed. This forms an investing layer for practically

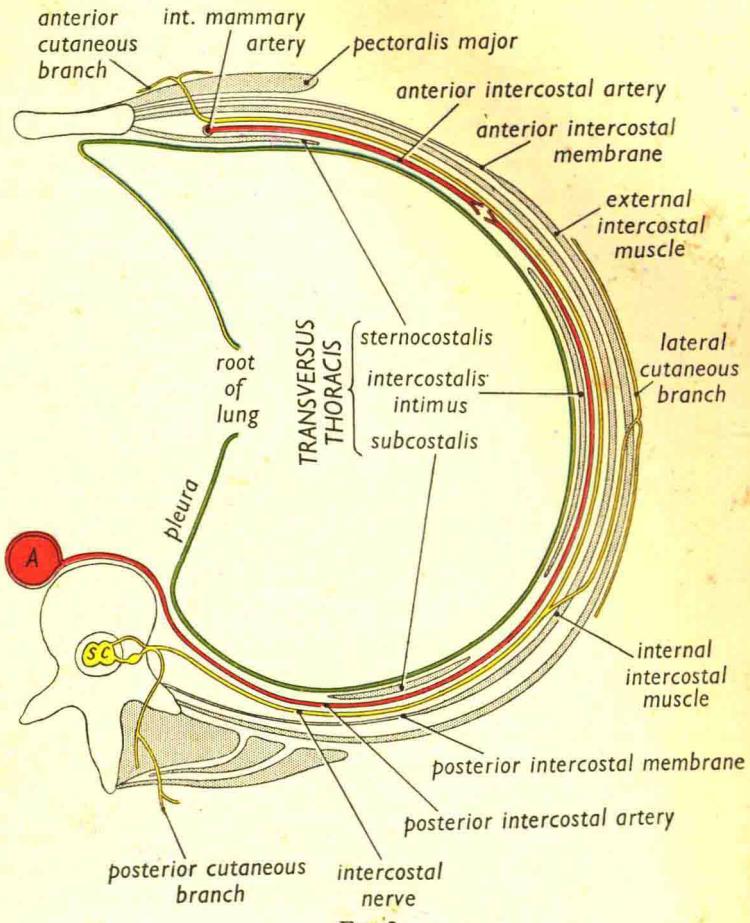

FIG. 2

Diagram of a section along an intercostal space showing the relations of the vessels and nerves to the muscular planes.

the whole of the body. In the dissected specimen it appears white, fibrous and tough, owing to the action of the preserving fluid, but in the living body it is almost transparent, slippery and smooth. This again allows some movement of one structure on another. Deep to the fascia on the front of the thorax are the muscle fibres of the **pectoralis major** (Fig. 1). Clean the fascia from the front of the muscle and examine the attachment of one head of the muscle to

the medial half of the front of the clavicle and of the other head to the front of the sternum, to the upper six costal cartilages and to the fascia on the front of the anterior abdominal wall. The other end of the muscle is attached to the humerus and some difficulty may be experienced in exposing the tendon.

Detach the pectoralis major from the clavicle, sternum and rib cartilages and turn the whole muscle laterally. While this is being done, pectoral nerves and vessels supplying the muscle are seen entering its deep surface. Try to preserve the nerves by detaching a small portion of the main mass of the muscle with them. By turning aside the pectoralis major the superficial layer of the anterior wall of the axilla is removed and the deep layer exposed. This consists of the clavicle above and the pectoralis minor below, with a sheet of fascia passing between the two structures, the **clavipectoral fascia.** Inferior to the clavicle and passing from it medially to the 1st rib is the **subclavius muscle,** which is enclosed by the clavipectoral fascia. The lateral pectoral nerve, the cephalic vein and branches of the axillary artery can be seen piercing the clavipectoral fascia. **Pectoralis minor** arises from the 3rd, 4th and 5th ribs and passes upwards and laterally to the scapula. Cut through its costal attachment and turn it laterally. After reflecting pectoralis minor, inspect and clean three muscles that are attached to the ribs. The first is the **rectus abdominis,** whose upper end arises from the xiphoid process and the 5th, 6th and 7th costal cartilages. The second is the **serratus anterior,** arising on the lateral side of the chest from the upper eight ribs. The third is the **external oblique** of the abdominal wall, which is attached to the lower eight ribs.

Cut through the costal attachments of the rectus abdominis and the external oblique and turn them downwards, but do not interfere with the serratus anterior; it must be left in position until the upper limb is dissected.

The intercostal spaces

Now dissect two or three intercostal spaces. Clean the first layer of muscle, the **external intercostal.** Note the direction of the fibres running downwards and forwards from one rib to the next and that the muscle ends at the level of the costochondral junction; this layer is continued to the sternum as the **anterior**

intercostal membrane (Fig. 2). Find the lateral branch of the **intercostal nerve** belonging to the space being dissected. This branch pierces the external intercostal muscle just in front of the mid-axillary line and will act as a guide to the trunk of the nerve. Follow the branch to the border of the rib forming the upper boundary of the space. Remove the periosteum from the surface of this rib and then, with bone forceps, remove the outer layer of bone cortex and the marrow. Carefully nibble away the inner layer of bone, thus exposing the fused periosteum and pleura. Cut through the upper attachment of the external intercostal muscle and turn the muscle down. The **internal intercostal muscle** is now exposed. Note that its fibres are at right angles to those of the external muscle. In the region of the angles of the ribs the internal intercostal muscle is replaced by the **posterior intercostal membrane** which extends as far medially as the vertebrae.

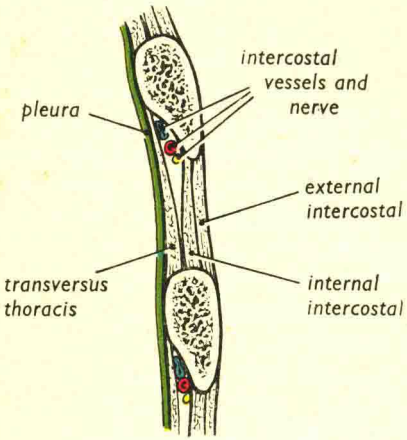

FIG. 3
Diagram of a vertical section through an intercostal space.

Cut through the upper attachment of the internal intercostal muscle and turn the muscle down. The intercostal vessels and nerve are found lying in the upper limit of the space, near the costal groove (Fig. 3). The lateral branch of the nerve can be traced into the main trunk. A very thin third layer of muscle may be present deep to the intercostal vessels and nerve and is called the **transversus thoracis muscle.** It does not form a complete sheet, and where the muscle fibres are deficient the gaps are filled by fibrous tissue. Lying deep to this layer is the lining membrane of the chest, the **pleura.**

Trace the nerve and vessels forwards to the anterior end of the intercostal space. The nerve terminates as a small twig that pierces the internal intercostal muscle and the anterior intercostal membrane and supplies the skin near the midline. The artery

gives off a twig running with the nerve and a smaller branch which anastomoses with a branch of the internal mammary artery. (These branches are small and often difficult to find.)

Clear away the remnants of the anterior intercostal membrane and the internal intercostal muscle from the anterior end of the space. Find the **internal mammary artery** lying 1 to 2 cm lateral to the side of the sternum in front of the sternocostalis part of the transversus thoracis muscle. Expose it in each space down to the upper border of the 6th rib by removing the sternal ends of the costal cartilages very carefully. In the 6th intercostal space the internal mammary artery divides into the **superior epigastric artery** and the more lateral **musculophrenic artery.**

After re-examining the intercostal muscles remove them from the intercostal spaces as far back as the attachment of the serratus anterior muscle. After detaching the pleura from the deep surfaces of the ribs, cut through the 2nd to the 8th ribs inclusive with bone forceps as far laterally as possible. Cut through the manubriosternal and xiphisternal joints with a saw. Detach the sternum, the costal cartilages (except the 1st) and the anterior parts of the ribs from the underlying tissues and lift them off, separating them from the pleura with the finger tips. The parietal layer of the pleura lining the chest wall is now exposed.

STRUCTURAL DETAILS

The vertebrae

The vertebral column transmits the weight of the body to the pelvis and legs, allows for flexibility, and protects the spinal cord. Weight is transmitted largely through the vertebral bodies, while the arches protect the cord. The segmental nature of the vertebral column allows flexibility and the movements are controlled by muscles attached to the processes of the vertebrae.

Each vertebra consists of a **body** (anterior) and an **arch** (posterior), which enclose the spinal cord. Adjacent vertebrae articulate by means of the bodies and the articular processes of the vertebral arches. The arch consists of the rounded **pedicles** directed backwards from the body and the flat **laminae** directed backwards and medially from the pedicles. In a typical thoracic vertebra there is, below the pedicle, a well-marked **inferior**

vertebral notch through which a spinal nerve leaves the vertebral canal. Projecting laterally and slightly backwards from the pedicles are the **transverse processes.** The **spinous process** is directed backwards and downwards from the point of fusion of the two laminae.

The facets on the **superior articular processes** of each thoracic vertebra articulate with the facets of the **inferior articular processes** of the vertebra above, and in the thoracic region these processes are found above (the superior) and below (the inferior) the junction of the pedicle with the transverse process. The arrangement of the facets is such that the main movement between individual vertebrae is a slight rotatory one. Note that the thoracic vertebrae vary in size and shape (*e.g.* obliquity of spinal processes). The upper vertebrae tend to show some of the characteristics of the cervical vertebrae in that the articular processes lie in a more oblique plane, and the edge of the vertebral body is lipped above the pedicle producing a superior as well as an inferior vertebral notch. The lower vertebrae tend to the characteristics of the lumbar vertebrae, especially marked in the 12th thoracic vertebra in which the inferior articular processes face laterally, the transverse processes carry an accessory process, and the spine is expanded and points backwards. The vertebral canal is larger at the upper and lower ends of the thorax than in the middle to accommodate the larger size of the spinal cord at these levels. Note also that although the number of thoracic vertebrae is in nearly all cases twelve, there may be eleven or thirteen, the ribs varying accordingly.

The 1st to the 10th ribs articulate with both the body and transverse process. On the side of each vertebral body at the upper and lower borders is a facet for articulation with the head of the rib. The head of each rib except the 1st, 10th, 11th and 12th articulates with two vertebrae and a disc. The 1st thoracic vertebra has a complete upper facet for the 1st rib, which does not articulate with the 7th cervical vertebra, and a small lower facet for the 2nd rib. The facets of the 10th, 11th and 12th vertebrae are usually single. The tubercles of the 1st to the 10th ribs articulate with the front of the transverse processes by means of synovial joints. The last two ribs do not have synovial joints with the transverse processes. In the upper thoracic vertebrae the articular facets on the transverse processes are concave, allowing

rotation but little gliding of the rib. In the lower vertebrae the facets are flatter and face upwards and forwards, allowing a gliding movement in which the posterior part of the rib is drawn upwards and backwards.

A typical vertebra **ossifies** from three primary centres (for the body and each half of the vertebral arch) and from five secondary centres (the spine, transverse processes and upper and lower surfaces of the body). The primary centres fuse together during the early years of life and the secondary centres, which appear at puberty, fuse by the twenty-fifth year (Fig. 4).

The sternum

The sternum is divided into three parts, the manubrium, body and xiphoid process, from above downwards.

The rhomboid-shaped **manubrium** has on its upper surface the **suprasternal notch ;** lateral to this on either side, facing laterally and upwards, are facets for the medial ends of the clavicles. The clavicular facet is smaller than the articular surface on the clavicle and the medial end of the clavicle projects above the sternum. Below the facet for the clavicle is the attachment for the first costal cartilage, which is joined to the bone by means of a **synchondrosis** (direct union of cartilage to bone), differing in this respect from the other sternochondral articulations, which are **synovial** (containing a joint cavity). The inferolateral angle of the manubrium articulates with the upper portion of the second costal cartilage. Its inferior edge articulates with the body of the sternum, and the two parts of the bone, not being in the same plane, form the prominent **sternal angle.** The joint between the manubrium and the body is a **symphysis,** the two bony surfaces being united by fibrocartilage. This allows a slight hinge movement of the body on the manubrium during inspiration. This joint may be **synostosed** (*i.e.* ossified) so that the manubrium and body are one piece. Attached to the side of the front of the manubrium is the pectoralis major muscle and just below and medial to the clavicular facet is the attachment of the sternal head of the sternomastoid muscle. Around the posterior margins of the clavicular facet are attached the sternohyoid and the sternothyroid muscles. These last three muscles will be dissected in the neck.