THE POST-NATAL DISTRIBUTION OF THE ABDOMINAL CHROMAFFIN TISSUE IN THE GUINEA-PIG, MOUSE AND WHITE RAT

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Groups of extra-adrenal chromaffin cells were observed by Stilling (1890) in association with the abdominal sympathetic plexuses of the cat, rabbit and dog and these cells were shown subsequently to resemble those of the adrenal medulla, not only in their affinity for chrome salts, but also in that pressor amines may be extracted from both elements (Biedl & Wiesel, 1902).

Much of the earlier work on the extra-adrenal chromaffin tissue was confined to the study of this material in man, and yet although human post-mortem material is satisfactory for determining the general topographical distribution of this tissue, it is often unsuitable for detailed cytological observations as a result of the ante-mortem, agonal and post-mortem changes which have affected the cells. Phaeochromocytes are highly reactive to a variety of stimuli. These may result from either starvation (Jackson, 1919) or the administration of hormones or drugs (Cramer, 1928; Hillarp, 1946; Coupland, 1959). Intense stimulation usually results in an increase in nuclear basophilia with some shrinkage and in cytoplasmic vacuolation. These changes may therefore be readily interpreted as signs of cellular degeneration in spite of the fact that they are reversible.

The earlier works on the distribution of chromaffin tissue in man have been summarized previously (Coupland, 1952, 1954). It is now generally accepted that much of the extra-adrenal chromaffin tissue disappears from its normal site during childhood, at between 3 and 7 years of age, and at a time when the adrenal medulla is approaching full development. The reason for this change is not as yet clear and the study of this problem in man is limited by the difficulty of obtaining really fresh material which is suitable for cytological observations. This problem has therefore been investigated in a number of lower mammals and for this work members of the cohort Glires have been used since they are readily obtainable and, in addition, many contain large amounts of extra-adrenal chromaffin tissue. Furthermore, at least one member of this cohort, the mouse, has been reported to possess extra-adrenal chromaffin bodies which disappear during the pre-pubertal phase (Goormaghtigh, 1935); a change which has some resemblance to that which occurs in man. According to Goormaghtigh (1935) the disappearance of these cells from the pre-aortic region is the result of a peripheral migration.

Detailed descriptions of the extra-adrenal abdominal chromaffin tissue of the rabbit already exist (Kohn, 1903), Coupland (1956). Only brief mention has, however, been made to this material in the guinea-pig, mouse and rat. Vincent (1910) was unable to demonstrate extra-adrenal chromaffin tissue in the guinea-pig, but its presence in this mammal was observed by Wislocki (1922). The only reference to this material in the rat would appear to be a letter from Kohn to Vincent (1910) in which Kohn stated that he had occasionally observed a discrete extra-adrenal chromaffin body in this animal. Vincent was, however, unable to find any evidence of para-aortic chromaffin bodies in the white rat.

MATERIALS AND METHODS

Guinea-pigs, strong A strain albino mice and Wistar strain rats were used. Guinea-pigs were aged 1, 2 and 5 days; 4 (two), 10, 14, 24 (two), 36 (two) and 80 weeks; two 6·5 cm. foetuses were also examined. Mice were aged 1 (three), 10, 14, 19, 21 (two), and 28 days (two); 8, 12 (two), 16 and 36 weeks (two); three 18 mm. foetuses were also examined. Rats aged 1 (two), 7 (two), 14 and 28 days were examined. Many of the specimens were litter-mates. Animals were killed by a blow on the head. The majority were fixed by perfusion with formol-dichromate (neutral formaldehyde 5%, potassium dichromate 3%) followed by immersion of blocks of the posterior abdominal wall and associated viscera in the fixative for 24 hr. The tissues were then washed, dehydrated and embedded in paraffin. Serial sections were made at 6–10 μ. Blocks obtained from the larger animals were cut into conveniently sized pieces after fixation but before embedding. Some specimens were fixed in Carnoy's fluid (6:3:1), Helly's fluid, formol-Zenker or Bouin's fluid. In most instances alternate slides were stained by Ehrlich's haematoxylin and Giemsa's stain. A few slides were stained by one of the following stains: iron haematoxylin, Mallory's trichrome, Feulgen's leucofuchsin or methyl green-pyronin. Graphic reconstructions of a number of specimens were made, using a camera lucida, in order to reveal the position of the chromaffin cells in relation to the abdominal aorta.

RESULTS

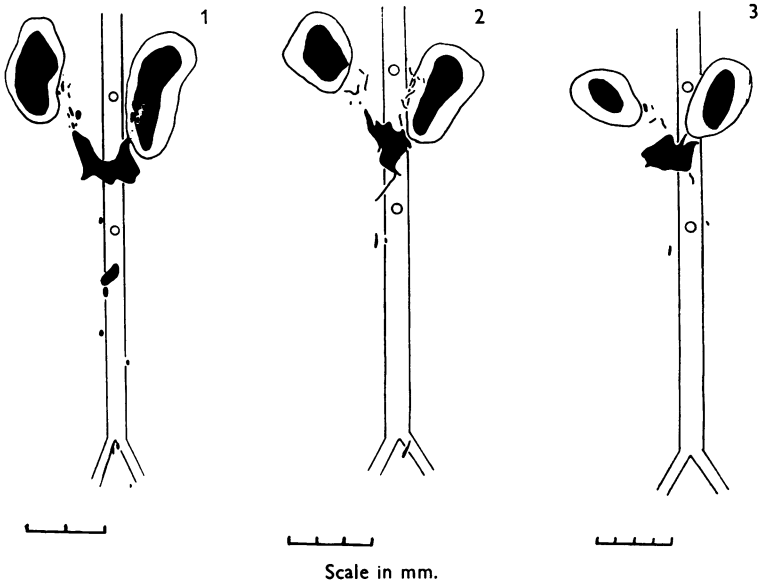
As no sex difference has been observed in the distribution of chromaffin tissue during the present work, the sex of the animals will not normally be specified.

GUINEA-PIG

6·5 cm. foetus

A well-marked chromaffin reaction is observed in the cells of the adrenal medulla and in cells associated with the abdominal sympathetic nerve plexuses. At this stage the adrenal medulla is relatively large and accounts for one-third of the diameter of the gland; it is composed mainly of chromaffin cells, but also contains sympathetic neurones which may be observed singly or in clumps. These neurones are occasionally associated with collections of small, darkly staining cells, which resemble small lymphocytes.

Extra-adrenal chromaffin cells occur singly or in groups in the pre-vertebral sympathetic ganglia. The largest collection of these cells lies between the origin of the superior and inferior mesenteric arteries (Text-fig. 1, Pl. 1, fig. 1) and measures from 1 to 2 mm. in cranio-caudal and transverse diameters. It is intimately associated with the fibres of the pre-aortic and renal sympathetic plexuses. The rostral part of this structure passes posterior to the left renal vein (Pl. 1, fig. 2). Smaller chromaffin bodies occur in the coeliac, superior and inferior mesenteric ganglia. These are often elongated structures and measure up to 0·5 mm. in long axis. In the lumbar para-vertebral sympathetic ganglia chromaffin cells are occasionally observed either singly or in small groups of up to four cells. Some ganglia are devoid of these elements whilst others contain more than one cell or group of cells. The main extra-adrenal chromaffin body contains small groups of sympathetic neurones but, as in the adrenal medulla, chromaffin cells predominate. The sympathetic neurones contain nuclei which measure 8–10 μ in diameter; nucleoli are prominent.



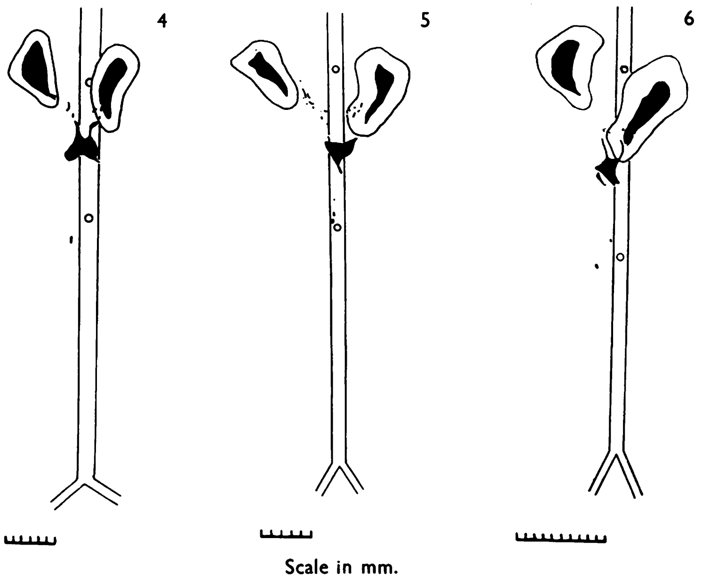
Text-figs. 1–3. Reconstructions of the chromaffin tissue of a 6·5 cm. guinea-pig foetus and post-natal specimens aged 1 day and 4 weeks, respectively. The aorta, with the origins of the superior and inferior mesenteric arteries, and the adrenal glands are also shown.

Irrespective of situation, each chromaffin cell has a round or ovoid nucleus which measures 6–8 μ in maximum diameter and contains three or four scattered granules of chromatin; these usually lie immediately beneath the nuclear membrane. Supporting connective tissue stroma is only observed after the use of silver stains for reticular tissue. Mitotic figures have been observed in both the adrenal medulla and extra-adrenal chromaffin tissue, and in the two specimens examined they are seen with an average frequency of 1 in 6 sections.

1–5 *days old*

The distribution of chromaffin tissue is indicated in Text-fig. 2. As in the previous specimen the main chromaffin body lies in the pre-aortic region (Pl. 1, fig. 3) between the origins of the superior and inferior mesenteric arteries and in the day-old specimen measures 2·4 mm. in a cranio-caudal direction and 1·6 mm. in transverse diameter. Its rostral extremity is crossed anteriorly by the right renal vein. A close association between this body and the pre-aortic and renal sympathetic plexuses is again apparent and has indeed been observed in all specimens irrespective of age. Smaller and more elongated collections of chromaffin cells, which may measure up to 0·5 mm. in long axis, are present in the coeliac and superior mesenteric ganglia (Pl. 1, fig. 4, Text-fig. 2).

The chromaffin cells give a stronger positive chromaffin reaction than those of the foetal specimens and many contain small cytoplasmic vacuoles (Pl. 1, figs. 5, 6). Mitotic figures have been observed in the adrenal medulla but have not been seen in the main extra-adrenal chromaffin body (every fourth serial section was examined). The connective tissue stroma of the latter is more abundant than in the previous specimen and routine stains now demonstrate the presence of collagenous fibres. All extra-adrenal chromaffin bodies are surrounded by a thin connective tissue capsule; this is most prominent in the main body.



Text-figs. 4–6. Reconstructions of the chromaffin tissue of guinea-pigs aged 10, 24 and 36 weeks, respectively. The aorta, with the origins of the superior and inferior mesenteric arteries, and the adrenal glands are also shown.

Sympathetic neurones are often associated with chromaffin cells, both inside and outside the adrenal gland; they are larger than those of the previous specimen and contain a nucleus which measures 10–15 μ in diameter.

4–80 *weeks*

In all these animals the pattern of distribution of chromaffin tissue is similar. Reconstructions of specimens aged 4, 10, 24 and 36 weeks are reproduced in Text-figs. 3–6.

Small encapsulated collections of phaeochromocytes which measure up to 0·5 mm.

in long axis, exist in the large pre-vertebral sympathetic ganglia and are most numerous in the coeliac and superior mesenteric collections of nerve cells. In each specimen the largest para-aortic chromaffin body conforms in position and relations to that of the earlier specimens but shows an increase in length and width (Text-fig. 13). These changes are associated with a reduction in the thickness of the body, as measured dorso-ventrally (Pl. 1, figs. 1, 3; Pl. 2, figs. 7, 9). Hence, with age the main body becomes wider, longer and flatter.

The extra-adrenal chromaffin cells are supported by a stroma which is rich in collagenous fibres. Collagen is most abundant in the main body and appears to increase in amount with age. In some of the small extra-adrenal chromaffin bodies, associated with the coeliac and superior mesenteric ganglia, blood-capillaries and thin walled veins form a conspicuous feature (Pl. 2, fig. 8).

No evidence of cellular infiltration of chromaffin tissue has been obtained in any of these animals and a well-defined healthy looking body still exists in the 80-week-old specimen (Pl. 2, fig. 9).

Phaeochromocytes have the same general structural features as in the earlier specimens and a positive chromaffin reaction is observed in both intra- and extra-adrenal cells, though in the adrenal medulla the reaction is usually stronger and of a darker brown variety than in the para-aortic bodies. Cytoplasmic vacuoles may be observed in any chromaffin cells but are usually larger in the extra-adrenal elements (Pl. 2, figs. 10, 11). In the adrenal medulla the cells are cuboidal or columnar in shape, are arranged around venous sinuses and are supported by a reticular stroma. In the para-aortic bodies, the chromaffin cells form cords in association with collagenous connective tissue and capillary blood vessels. Towards the lateral extremities of the main para-aortic bodies the chromaffin cells are seen to be aligned with their long axes running more or less transversely and parallel to the fibres of the renal sympathetic plexus; elsewhere they are arranged irregularly. Examination of each fourth section through the entire adrenal medulla and main para-aortic chromaffin body in specimens aged 10, 24 and 36 weeks has failed to reveal the presence of mitotic figures. There is no definite evidence of degeneration of these elements.

As in earlier specimens, chromaffin cells are occasionally observed singly or in small groups in the lumbar para-vertebral sympathetic ganglia: they are inconstant in position and some ganglia are free from these elements.

Small collections of ectopic adrenal cortex exist in specimens aged 10, 14 and 28 weeks. They lie near the upper poles of the kidneys and in the immediate vicinity of the adrenal gland.

MOUSE

18 *mm. foetus*

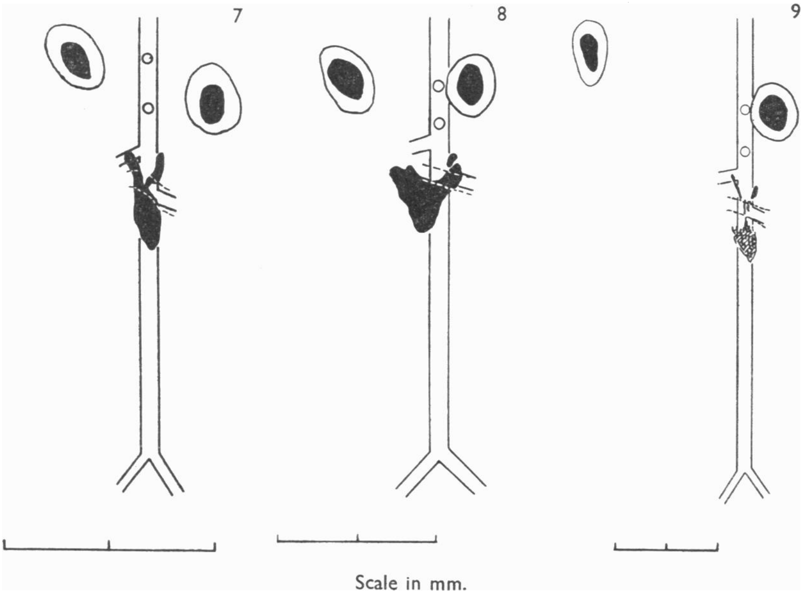
Sections through the adrenal glands show a well-defined cortex and medulla. The medulla occasionally reaches the surface at the lower medial aspect of the gland but is not continuous with extra-adrenal chromaffin tissue. The medullary cells give a very faint positive chromaffin reaction.

A compact mass of chromaffin tissue lies anterior to the aorta immediately caudal to the left renal vein, its upper extremities embracing the latter structure. The body lies inferior to the origin of the right renal artery, but overlaps that of the left renal artery and extends some 300 μ below this level.

No extra-adrenal phaeochromocytes have been observed elsewhere at this stage, but this fact does not preclude the presence of small groups of these cells, since the chromaffin reaction is so faint that isolated cells or small aggregations could easily be overlooked.

1–19 *days old*

The distribution of chromaffin tissue is indicated in the reconstructions Text-figs. 7, 8.



Text-figs. 7–9. Reconstructions of the chromaffin tissue of mice aged 1, 10 and 21 days, respectively. The aorta (with origins of the coeliac, superior mesenteric and renal arteries), the left renal vein and the adrenal glands are also shown.

A positive chromaffin reaction, which increases in intensity from faint in the day-old specimen to moderately intense in the 19-day-old mouse, is given by the cells of the adrenal medulla and a large compact chromaffin body which lies anterior to the aorta (Pl. 2, fig. 12; Pl. 3, figs. 13–15). In the adrenal medulla the reaction is patchy and some groups of cells give a stronger reaction than others. In the extra-adrenal body the reaction is uniform throughout. Other smaller collections of up to four chromaffin cells occur inconstantly in the pre- and para-vertebral sympathetic ganglia. The greater part of the main extra-adrenal chromaffin body lies caudal to the left renal vein, while its upper extremity embraces this structure (Pl. 3, fig. 13).

The adrenal phaeochromocytes have rounded or ovoid nuclei 6–8 μ in diameter which contain scattered granules of chromatin. The extra-adrenal cells are smaller and contain ovoid nuclei, which measure 5–7 μ in diameter. In the 1- to 10-day-old animals all chromaffin cells are supported by a reticular connective tissue stroma but in the 14- and 19-day-old specimens collagenous fibres are present. Mitotic figures are present in both intra- and extra-adrenal chromaffin cells in all specimens and at 14 days have a frequency of 1 in 10 sections.

21 *days*

The chromaffin cells of the main para-aortic body extend over a greater distance in a cranio-caudal direction than in any previous specimen (Text-fig. 9). Some cells appear to have become detached from the rostral extremities of the body and others lying below the level of the left renal vein no longer form a compact mass (Pl. 3, fig. 16). Occasional pyknotic nuclei are observed in the chromaffin cells of the main body. Small para-aortic chromaffin bodies of less than 100μ in diameter lie in the renal plexus adjacent to the hilum of the kidney on the right side, and in association with sympathetic neurones in the caudal part of the pre-aortic sympathetic plexus.

Vagal paraganglia have been observed in association with the nerve fibres of the superior mesenteric and coeliac plexuses. These are encapsulated structures composed of small cells whose nuclei measure 5–6μ in diameter and contain prominent chromatin granules: the cytoplasm of these elements gives a negative chromaffin reaction.

4–36 *weeks*

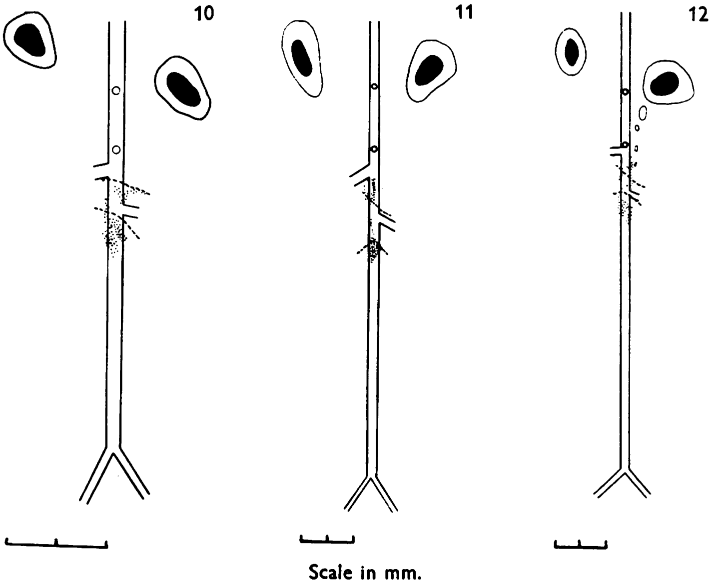
The disruption of the formerly compact extra-adrenal chromaffin body first observed in specimens aged 21 days becomes more marked as the age of the animal increases and in all these specimens the pre-aortic region rostral, dorsal and caudal to the left renal vein contains irregular groups or cords of chromaffin cells (Pl. 3, figs. 17, 18). These elements have not been observed extending along the distal ramifications of the pre-vertebral sympathetic plexuses and there is therefore no reason to suppose that a distal migration of chromaffin elements occurs. Small groups of up to three phaeochromocytes have been observed in the ganglia of the hypogastric plexus and of the lumbar sympathetic chain; they are, however, inconstantly present.

The chromaffin reaction is moderately intense in all situations but in the adrenal gland the intensity of the reaction varies from one group of cells to another; the reaction in the extra-adrenal elements is more uniform. The medullary phaeochromocytes contain rounded nuclei, 6–8μ in diameter and have an abundant cytoplasm. The extra-adrenal cells contain round or ovoid nuclei 5–7μ in diameter, cytoplasm being scanty. Nuclei in both situations contain scattered chromatin granules and nucleoli are often visible. An occasional pyknotic nucleus is observed in chromaffin cells of the pre-aortic region and although an accurate estimate of the number of cells present before and after the disintegration of the main extra-adrenal chromaffin body is virtually impossible because of the scatter of these elements, it would appear that in the 36-week-old specimen the number is less than in younger animals.

In a 12-week-old pregnant female specimen (Text-fig. 12) four masses of ectopic adrenal cortex lie caudal to the left adrenal gland. In one of these degenerative changes identical with those which affect the X-zone of the adrenal cortex may be observed.

RAT

In one 7-day-old specimen a small collection of chromaffin cells, 25μ in diameter, was observed in the pre-aortic sympathetic plexus immediately caudal to the superior mesenteric artery; in the others no extra-adrenal chromaffin cells were observed.



Text-figs. 10–12. Reconstructions of the chromaffin tissue of mice aged 4, 8 and 12 weeks, respectively. The aorta (with origins of the coeliac, superior mesenteric and renal arteries), the left renal vein, the adrenal glands, and, in Text-fig. 12, ectopic adrenal cortex are also shown.

DISCUSSION

During the present work six Wistar strain albino rats, aged 1–28 days, have been examined. In five of these animals no evidence of extra-adrenal chromaffin cells has been obtained, while in one a small discrete collection of these cells was observed adjacent to the superior mesenteric artery. It would appear, therefore, that in the abdomen of the rat the chromaffin tissue is virtually confined to the adrenal gland.

In both the new-born mouse and guinea-pig a large well-defined chromaffin body exists in the pre-aortic region. In the guinea-pig this persists throughout life, while in the mouse the structure begins to disintegrate in animals aged 3–4 weeks and only small scattered groups of chromaffin cells remain in older animals. No evidence of a true peripheral migration of these elements, as suggested by Goormaghtigh (1935), has, however, been obtained. In both the mouse and guinea-pig the main para-aortic chromaffin body is closely related to the left renal vein and its rostral extremity often embraces this structure. In the guinea-pig the body is triangular or rectangular in shape and is closely associated with both the obliquely running fibres of the renal plexus and with the longitudinal fibres of the pre-aortic sympathetic plexus. Its disposition and associations are therefore different from those of the main para-aortic bodies of man (Coupland, 1954) and rabbit (Coupland, 1956), which are associated only with the longitudinally running fibres of the pre-aortic plexus.

The enlargement of the main para-aortic body of the guinea-pig, between birth and 4 weeks old, is associated with an increase in supporting stroma, which changes from a reticular type, present in the foetus, to one in which collagenous fibres are evident. This change is similar to the one that takes place in the extra-adrenal chromaffin bodies of both man and rabbit and there is no reason to suppose that it is *per se* a sign of degeneration. The increase in stroma is often more apparent in perivascular sites than elsewhere, but endarteritis has never been observed. Indeed, capillary type blood vessels are often more apparent in older specimens, particularly in the rabbit and guinea-pig. The increase in perivascular fibrous tissue observed in man, rabbit and guinea-pig may, therefore, be an incidental phenomenon unrelated to the well being of the chromaffin elements, since identical changes may be observed in other vessels in the pre-aortic region.

Cellular infiltration of the para-aortic bodies has not been observed in the present work. This result is in keeping with the findings in man and rabbit (Coupland, 1954, 1956). Nuclear pyknosis has very occasionally been observed in the phaeochromocytes of both guinea-pig and mouse, and has been more commonly observed in the extra-adrenal cells than in those which form the adrenal medulla. The significance of nuclear pyknosis in chromaffin tissue is, however, difficult to assess, since, as noted above, cytoplasmic vacuolation and nuclear pyknosis can very readily be produced in chromaffin cells by a variety of stimuli. It does, however, appear likely that in the mouse, some of the pre-aortic chromaffin cells do undergo degeneration after the disintegration of the main chromaffin body.

During the present investigation and in previous works (Coupland, 1954, 1956) the detailed distribution of chromaffin tissue in the abdomen of man, rabbit, mouse and guinea-pig has been observed and the changes which affect this tissue during the growing phase, from birth to sexual maturity or later, have been noted. In all these animals, at birth and for a short time thereafter, a large number of phaeochromocytes exists in the pre-aortic region and forms a main extra-adrenal chromaffin body. Other small bodies may be associated with any part of the pre-vertebral sympathetic nervous system and chromaffin cells are not uncommonly observed in the ganglia of the lumbar sympathetic chain. During the pre-pubertal phase the main extra-adrenal chromaffin bodies show changes in disposition. In man the bodies (organs of Zuckerkandl) first elongate and then disintegrate during childhood, the constituent cells being scattered between the fibres of the pre-aortic sympathetic nerves. In the mouse the body first elongates and then disintegrates in the 3- to 4-week-old animal. In the rabbit the body merely elongates. In the guinea-pig the body increases in overall dimensions in both longitudinal and transverse directions. It should be noted that these changes affect only the largest para-aortic body, the smaller more compact masses persisting in both pre- and para-vertebral ganglia. This selectivity suggests that local factors may be involved in the changes which take place.

It has been generally accepted for many years that the chromaffin system reaches maturity at an early stage after birth (Elliott & Tuckett, 1906) and the time of occurrence of mitotic figures in both the adrenal medulla and para-aortic bodies during this investigation would support this contention. Extra-adrenal chromaffin bodies are encapsulated structures made up of phaeochromocytes, sympathetic nerve fibres, and a variable amount of connective tissue stroma. The main bodies lie with their long axes directed cranio-caudally and are in intimate association with the longitudinally running fibres of the pre-aortic sympathetic plexus. In the guinea-pig the main body is also closely associated with the more transversely disposed fibres of the renal plexus. The pre-aortic sympathetic nerve fibres will of necessity undergo a considerable increase in length as the animal grows: the change being roughly equal to that which affects the abdominal aorta. The growth of these nerve fibres must, therefore, be accompanied by a change in the structural form or arrangement of the contiguous chromaffin bodies. It is apparent from Table 1 that the bodies elongate as the animals age. It should, however, also be noted (Table 1, Text-fig. 13) that in the rabbit and mouse, the length of the main chromaffin body (or cells derived therefrom) bears a constant relation to the length of the abdominal aorta, irrespective of age, and that the body ceases to elongate at the same time as the aorta. As indicated above, the extra-adrenal chromaffin bodies mature soon after birth and mitotic figures are few or absent in these structures throughout the greater part of the pre-pubertal growing phase of man, rabbit, guinea-pig and mouse. The change in the form of the chromaffin bodies is not, therefore, the result of a proliferation of phaeochromocytes. The present

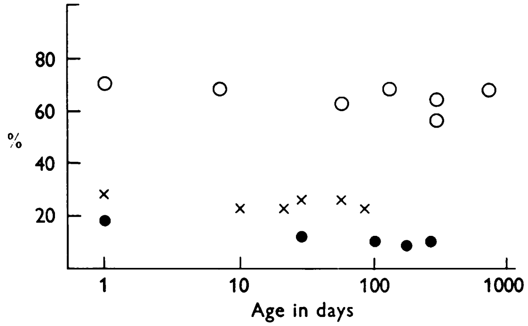
Table 1

Variation in length of aorta aud main para-aortic chromaffin bodies with age

Animal	Age	Length of aorta* (mm.)	Length of P.A.B. (mm.)		P.A.B. as % length of aorta
Man	5 months	30·0	8·5		28
	18 months	27·0	11·0		40
	3 years	43·0	20·0		47
	5 years	52·0	32·0		61
	7 years	58·0	46·0		80
Rabbit	1 day	7·6	5·4		70
	7 days	16·0	10·8		68
	8 weeks	34·0	24·0		62
	16 weeks	61·0	42·0		68
	40 weeks	63·0	35·0		56
	40 weeks	70·0	43·0		62
	100 weeks	78·0	53·0		68
Mouse	1 day	3·3	0·9		28
	10 days	4·6	1·0		23
	21 days	6·4	1·4		23
	4 weeks	6·3	1·6		26
	8 weeks	12·0	3·1		26
	12 weeks	12·7	2·8		22
			P.A.B.		
			Length (mm.)	Width (mm.)	
Guinea-pig	6·5 cm. foetus	8·7	1·4	1·7	16
	1 day	13·6	2·4	1·6	18
	4 weeks	21·0	2·5	3·1	12
	14 weeks	47·0	5·0	4·0	10
	24 weeks	40·0	3·6	3·3	9
	36 weeks	44·0	5·0	3·0	11

* Length of aorta measured from superior mesenteric artery to bifurcation.

findings are, however, entirely in keeping with this change being passive in type and due to traction exerted by the elongating nerve fibres. In both guinea-pig and man during the growing phase the length of the main chromaffin body bears a less constant relation to the length of the aorta. This difference could, however, be accounted for, in the case of the guinea-pig, by the close association of the body with the fibres of the renal plexus, which may result in the relatively marked increase in the transverse as well as the longitudinal dimensions of the organ (Table 1), while in man, the size and shape of the main body or bodies is so variable that no close correlation can be expected. It is, therefore, suggested that the differential growth of the sympathetic nerve fibres and chromaffin bodies results in mechanical forces which distort the bodies and result, in the rabbit, in an alignment of the phaeochromocytes with their long axis parallel to the aorta and pre-aortic nerve fibres (Coupland, 1956), while in the guinea-pig some chromaffin cells become aligned with their long axis parallel to the obliquely running fibres of the renal sympathetic plexus. It is, furthermore, suggested that in man and in the mouse, where the stroma of the bodies is minimal, this mechanical effect is sufficient to disrupt the structures completely, the cells being scattered in the pre-aortic region, whereas, in the rabbit and guinea-pig the supporting connective stroma is sufficiently abundant to prevent this dispersal.



Text-fig. 13. Length of the main para-aortic body of rabbit, mouse and guinea-pig, expressed as a percentage of the length of the aorta (from superior mesenteric artery to bifurcation) at different ages. Ordinate: percentage length of body. Abscissa: age in days (log scale). ●, rabbit; ×, mouse; ○, guinea-pig.

The fate of the scattered chromaffin cells which result from the disintegration of the main body in both man and mouse is difficult to assess, but, though it is more difficult to recognize isolated chromaffin cells than groups of these elements, it would seem that many do actually disappear.

The chromaffin cells of the smaller para-aortic bodies form circumscribed masses which are usually embedded in and completely surrounded by nervous elements. The adjacent nerve fibres are arranged irregularly. In consequence, the mechanical stresses which must result from the differential growth of the cells and nerve fibres, would be expected to have a less obvious effect on these structures than on the main bodies. The persistence of these elements with some slight modification is in accord with the above hypothesis.

In the mouse numerous vagal paraganglia, originally described by Goormaghtigh (1935), have been observed in association with fibres of the superior mesenteric plexus. The constituent cells are smaller than the chromaffin elements and do not give a positive chromaffin reaction. They persist in the adult animal and degenerative changes have not been observed in these cells.

Many collections of ectopic adrenal cortex have been observed in both the guinea-pig and mouse. In a 12-week-old female mouse one mass of ectopic adrenal cortex showed degenerative changes which were identical with those which affected the X-zone of the normal adrenal cortex. None of these ectopic collections of cells contained chromaffin elements.

SUMMARY

In the new-born guinea-pig and mouse a large discrete para-aortic chromaffin body lies in the pre-aortic region adjacent to the renal vessels.

In the guinea-pig the body alters in shape during the pre-pubertal phase of growth and the connective tissue stroma changes from a reticular to a collagenous fibrous type. A discrete healthy looking body still remains, however, in the 80-week-old specimen.

The main chromaffin body of the 3-week-old mouse disintegrates: some of the constituent phaeochromocytes degenerate, others persist and form small groups in the pre-aortic region. There is no evidence of a peripheral migration of chromaffin cells.

Cellular infiltration and widespread degeneration of the chromaffin bodies has not been observed and it is suggested that, in these animals as also in man and rabbit, the changes in the form of the main para-aortic bodies during the pre-pubertal phase of growth, are the result of mechanical forces; these forces being produced by the differential growth of sympathetic nerve fibres and contiguous chromaffin elements.

Small discrete chromaffin bodies exist in the pre-vertebral sympathetic ganglia of the guinea-pig, but have not been observed in the mouse. In both animals small non-encapsulated collections of chromaffin cells may be found in the ganglia of the lumbar para-vertebral sympathetic chain.

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EXPLANATION OF PLATES

Abbreviations: *A* = aorta; *P.A.B.* = para-aortic chromaffin body; *S.N.* = sympathetic neurones; *L.V.* = left renal vein.

Plate 1

Fig. 1. Transverse section through the main para-aortic body of a 6·5 cm. guinea-pig foetus. Formol-dichromate. Haematoxylin. (×35.)

Fig. 2. Transverse section through the rostral extremity of the main para-aortic body of a 6·5 cm. guinea-pig foetus. Formol-dichromate, haematoxylin. (×35.)

Fig. 3. Transverse section through the main para-aortic body of a 2-day-old guinea-pig. Formol-dichromate, haematoxylin. (×90.)

Fig. 4. Section through a small para-aortic chromaffin body lying in the coeliac ganglion of a 2-day-old guinea-pig. Formol-dichromate, haematoxylin. (×400).

Fig. 5. Chromaffin cells in the adrenal medulla of a 2-day-old guinea-pig. Formol-dichromate, haematoxylin. (×650.)

Fig. 6. Chromaffin cells of the main para-aortic body of a two-day-old guinea-pig. Formol-dichromate, haematoxylin. (×650).

Plate 2

Fig. 7. Transverse section through the main para-aortic body of a 24-week-old guinea-pig. Formol-dichromate, Giemsa. (×50.)

Fig. 8. Section through a small para-aortic body lying in the coeliac ganglion of a 24-week-old guinea-pig. Formol-dichromate, haematoxylin. (×200.)

Fig. 9. Transverse section through the main para-aortic body of an 80-week-old guinea-pig. Formol-dichromate, haematoxylin. (×90.)

Fig. 10. Chromaffin cells of the adrenal medulla of an 80-week-old guinea-pig. Formol-dichromate, haematoxylin. (×650.)

Fig. 11. Chromaffin cells of the main para-aortic body of an 80-week-old guinea-pig. Formol-dichromate, haematoxylin. (×650.)

Fig. 12. Transverse section through the main para-aortic body of a day-old mouse. Formol-dichromate, haematoxylin. (×120.)

Plate 3

Fig. 13. Transverse section through the rostral extremity of the main para-aortic body of a day-old mouse. Formol-dichromate, haematoxylin. (×120.)

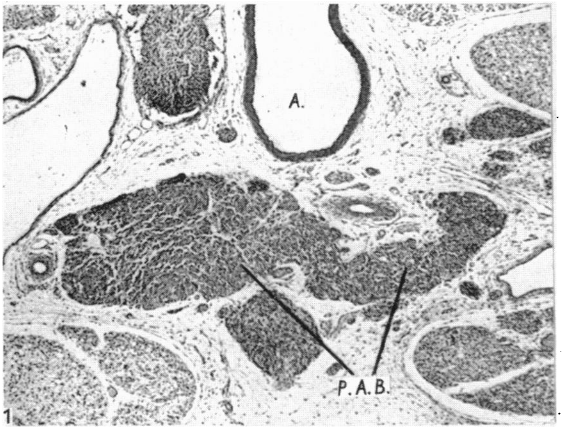
Fig. 14. Transverse section through the main para-aortic body of a 14-day-old mouse. Formol-dichromate, Giemsa. (×120.)

Fig. 15. Chromaffin cells of the main para-aortic body of a 14-day-old mouse. Formol-dichromate, Giemsa. (×500.)

Fig. 16. Transverse section through a 21-day-old mouse passing just caudal to the origin of the left renal artery. Formol-dichromate, haematoxylin. (×120.)

Fig. 17. Transverse section through a 4-week-old mouse passing just caudal to the origin of the left renal artery. Formol-dichromate, haematoxylin. (×120.)

Fig. 18. Chromaffin cells lying in the pre-aortic region of an 8-week-old mouse in the site originally occupied by the main para-aortic body. Formol-dichromate, Giemsa. (×540.)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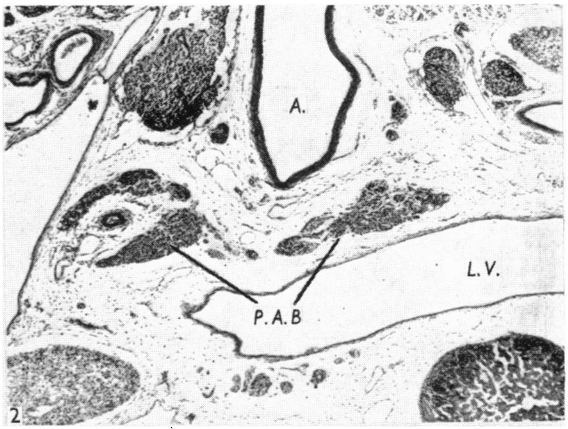
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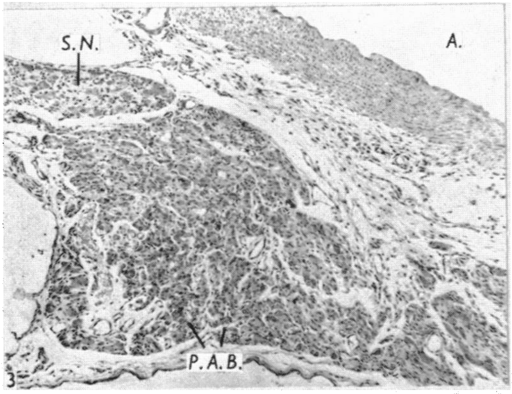
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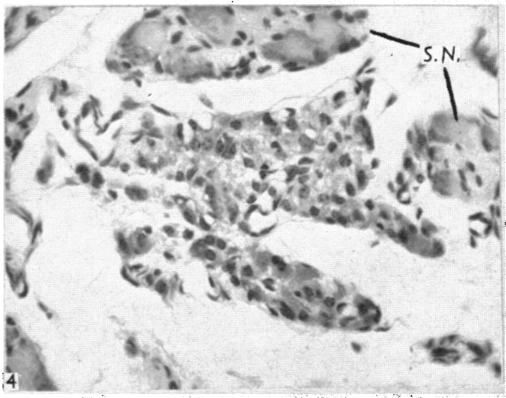
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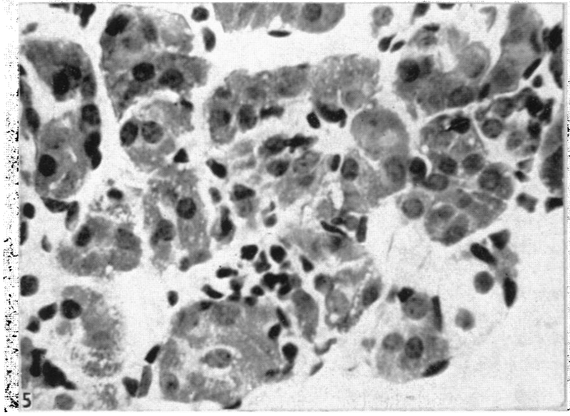
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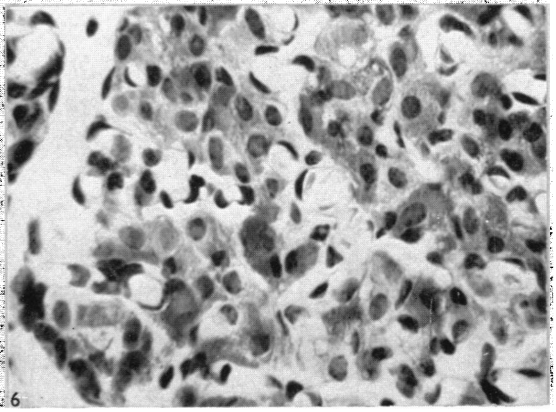
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COUPLAND—Post-natal distribution of the abdominal chromaffin tissue

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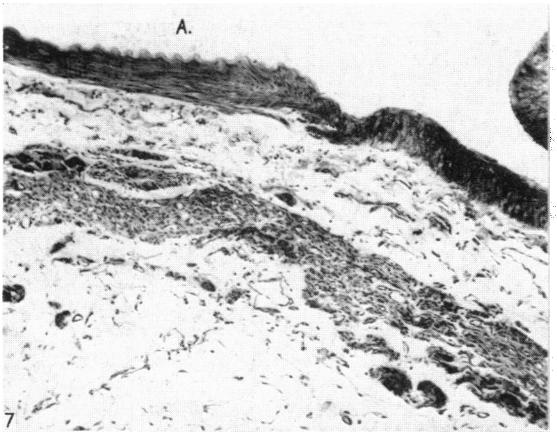

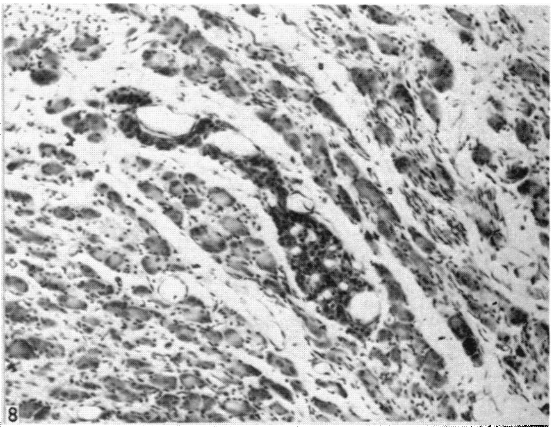

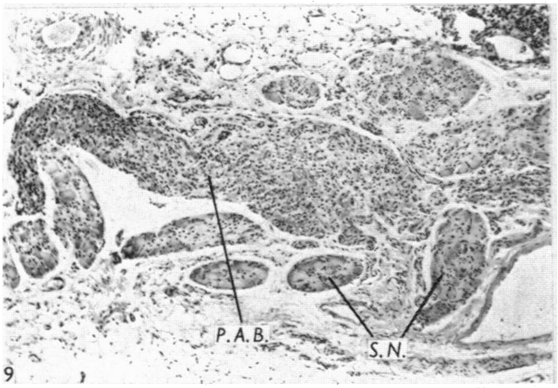

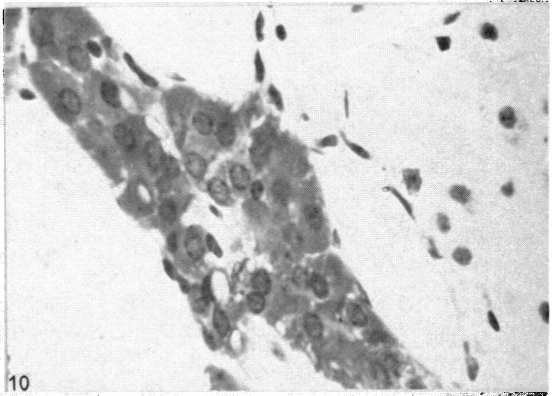

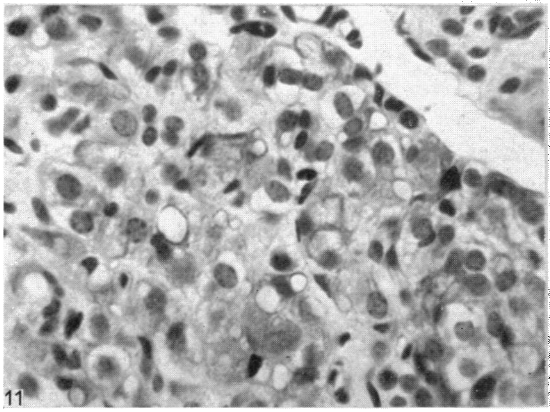

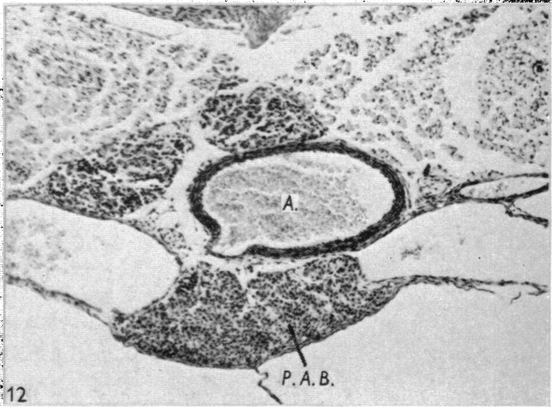

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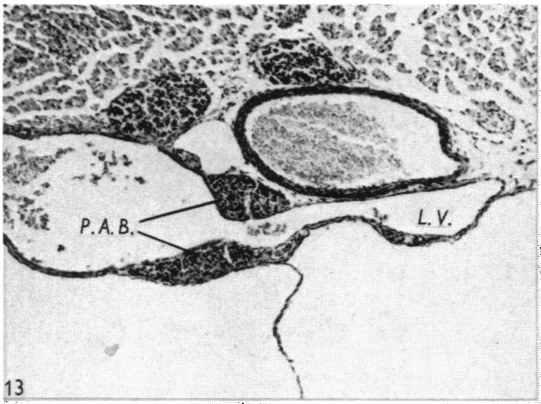

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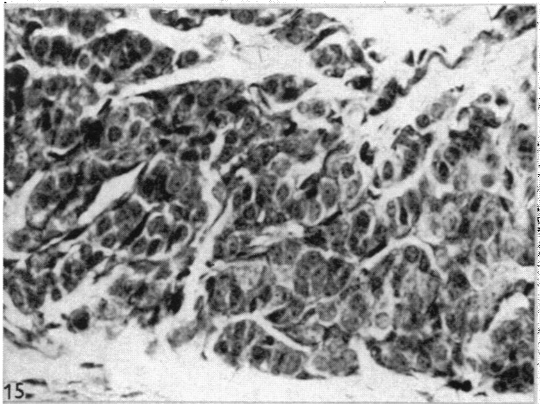

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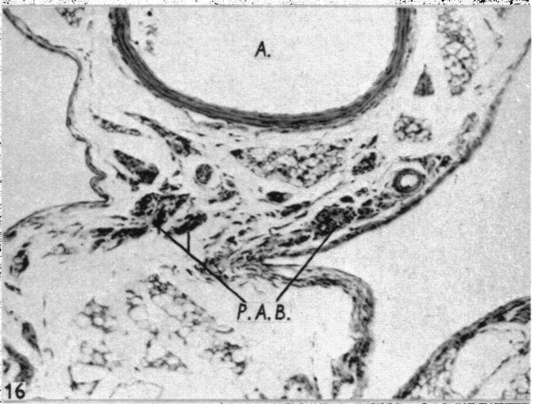

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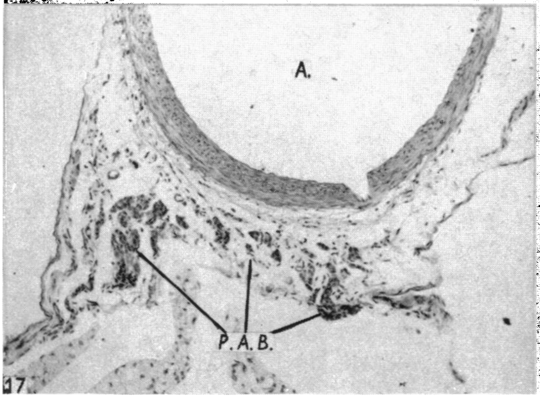

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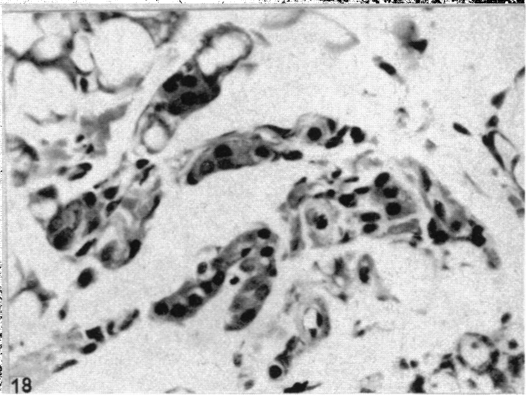

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COUPLAND—POST-NATAL DISTRIBUTION OF THE ABDOMINAL CHROMAFFIN TISSUE