

From: Department of Anatomy,
The Royal Dental College,
Aarhus, Denmark.

FUSION OF UPPER INCISORS AT BUD OR CAP STAGE IN MOUSE EMBRYOS WITH EXENCEPH- ALY INDUCED BY HYPERVITAMINOSIS A

by

P. A. KNUDSEN

INTRODUCTION

In the last days before delivery, haemorrhage and necroses occur in the brains of exencephalic mouse embryos. To avoid the consequent destruction and its effect on a projected morphological description of the brain, a number of embryos with exencephaly induced by vitamin A overdosage were removed from the uterus on the 15th or 16th day of gestation. All histological sections engaging the oral cavity and adjacent regions were examined to ascertain whether the brain defect is accompanied by anomalies in the oral cavity and tooth germ. It was originally intended to include young exencephalic embryos in an earlier study of malformed incisor germs (*Knudsen, 1965 [1]*). The tooth germs of these embryos are at such a primitive stage of development, however, that they are difficult to compare with those of older embryos. This, and various difficulties in interpretation described below, led to the young embryos being set aside for a special investigation, the results of which are presented here. The object has been to determine whether the fusion

This investigation was supported by grants from The Danish State Research Foundation and Fonden til fremme af videnskabelig og praktisk odontologi.

of the incisor germs of the upper jaw, which is found in 51 % of more mature exencephalic embryos, can be recognized at an earlier stage of tooth development; furthermore, whether it is possible to determine as early as the bud stage whether a fusion will proceed to *fusio partialis*, *subtotalis* or *totalis*. Finally, a morphological description of the primitive germs is given on the basis of models.

MATERIAL AND METHODS

The material comprises 37 mouse embryos, with exencephaly induced by administration of 4,000—10,000 I.U. vitamin A to the mother on the 7th to 9th day of gestation. The embryos were removed on the 15th or 16th day and fixed in Bouin's fluid. The heads were embedded in paraffin and sectioned serially. The plane of sectioning was frontal. Section thickness was 7 or 10 μ . The stain was haematoxylin-eosin in most cases, but a few series were stained by the pentachrome technique of *Movat* (1955). A large number of photomicrographs of incisor germs was taken, in order to compare germs from different embryos. 10 normal embryos of the same age were also examined. Finally, the external outline of tooth buds and oral epithelium in the roof of the oral cavity was traced at high linear magnification ($\times 200$) and four wax models were constructed. The models show tooth buds from 15 day-old embryos -- one normal and three exencephalic -- with varying degrees of *fusio dentium*.

RESULTS

The same classification of changes in the incisor germs has been used for young exencephalic embryos as for older embryos (Text Fig. 1). While in *fusio partialis* misinterpretation is possible, it has not proved difficult to determine the more extreme degrees of *fusio dentium*: *fusio totalis* and *subtotalis*.

In frontal serial sections of *fusio totalis* at the bud stage, the labial (anterior) part of the germ appears as a circular or oval cell accumulation, completely surrounded by mesenchyme (Figs.

4 a and b). This apparent separation from the oral epithelium is seen in several sections while the size of the germ is increasing. When connection with the epithelium is established in the sections, it first appears as a narrow stalk (Fig. 4 c), the width of which increases only slowly in the lingual (posterior) direction, and as the tooth bud keeps its rounded shape, the whole germ resembles a mushroom. The lingual part of the germ shows no sign of 'cleavage', even though it becomes broader and flatter. The connection with the oral epithelium is almost as wide as the entire germ (Figs. 4 d and e).

In *fusio subtotalis* there is likewise fusion in the labial part of the germ (Figs. 3 a and b) and not until a varying distance in the lingual direction do two buds with a connecting bridge of epithelium appear (Figs. 3 d and e). The fused labial part, which in frontal sections is separated from the oral epithelium by connective tissue, may be oval or nearly circular and thereby strongly resemble *fusio totalis*. Although the germ in *fusio subtotalis* may have considerable lateral extent, the connection with the oral epithelium is narrow labially (Fig. 3 c).

The least pronounced connection between germs at the bud stage is a thickening of the oral epithelium between the central parts of the germs, whilst the epithelium remains thin labially and lingually. At the beginning of this investigation, every thickening of the epithelial bridge was considered an early stage of *fusio partialis*. Only when an examination of older embryos showed 42.2 % exhibiting an incisal connection between the stellate reticula of the enamel organs in otherwise separate incisor germs did it become apparent that a connection between germs at the bud stage is not always a sign of *fusio partialis*. A moderate epithelial thickening probably develops into a connection between the stellate reticula of two otherwise isolated germs. In a new examination of the embryos with supposed *fusio partialis*, the majority were rejected, as by comparing photomicrographs and studying wax models it has been possible to lay down various criteria, the most important of which must be fulfilled, for the term *fusio partialis* to be correctly applied. A diagrammatic representation of the criteria is given in Text Fig. I: *fusio epithelialis* (III) and *fusio partialis* (IV). The criteria are as follows,

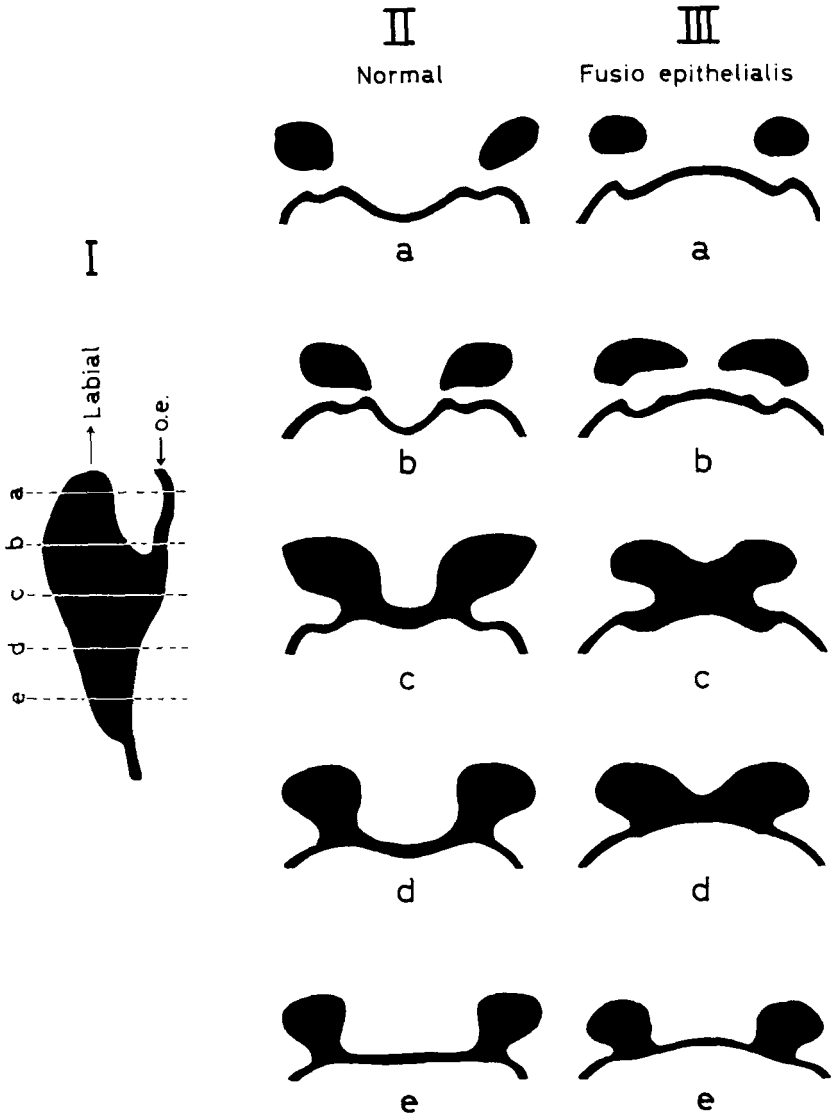
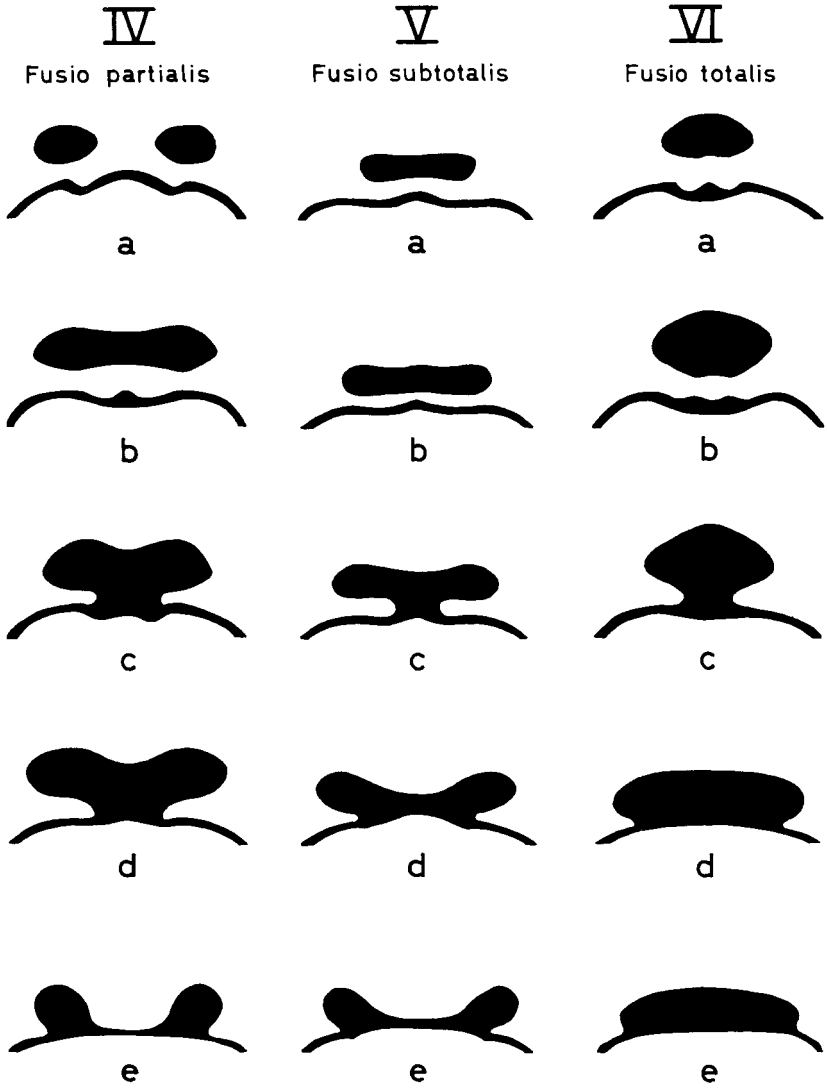


Fig. 1. Diagrammatic representation of frontal sections of upper incisor germs at the bud stage in a normal embryo and in exencephalic embryos with various degrees of fusio dentium.

Fusio epithelialis (III) indicates that, in later stages, there will only be connection between the incisal ends of the enamel organs. III and IV show the difference between fusio epithelialis and fusio partialis (see text). The location of the frontal sections used in the figures on the right (II—VI) is given on the sagittal section on the left (I). oe: oral epithelium.



1) *In frontal sections the labial part of the fused germs is separated from the oral epithelium, in fusio partialis*

On the first (labial) frontal sections, the germ appears as two distinctly separate cell accumulations, one on each side of the mid-line, showing that fusion is absent at the extreme labial end (Fig. 2 a). As the non-fused portion of the germ is short, a single broad cell accumulation, crossing the mid-line, is seen after only a few sections (Fig. 2 b). The cell accumulation is surrounded by mesenchyme and in several frontal sections it is without connection with the oral epithelium.

When the germs would later form a connection only between the incisal portions of the stellate reticula, a cell accumulation is seen on each side of the mid-line, without connection with the oral epithelium, in a larger number of frontal sections than is the case with *fusio partialis* (Figs. 1 a and b. Text Fig. 1: *Fusio epithelialis*). The absence of the unpaired isolated cell accumulation indicates that the connection across the mid-line between the central parts of the germs is short in the labio-lingual direction. Connection across the mid-line is not seen until the germs are connected to the oral epithelium (Fig. 1 c).

2) *Along the mid-line, the fused portion of the germs has almost the same height as the side portions, in fusio partialis*

In *fusio partialis* the mid-portion will only be a little lower than the side portions (Figs. 2 c and d. Figs. 1 c and d). It is only at the bud stage that doubt can arise; in the cap stage with connection only between the enamel organs, there will be a noticeable difference in height, on account of the strong growth of the side portions.

3) *The distance between the right and left parts of the germs is shortest, both labially and lingually, in fusio partialis* (Figs. 2 a and e, Figs. 1 a and e)

As it has been established that in older embryos the distance is often short between germs that are only connected across the mid-line by the stellate reticula, it is necessary to include the first two more certain criteria in any evaluation.

As a less certain criterion it can be stated that

4) *The stalk connecting the germs to the oral epithelium is as a rule narrowest in fusio partialis* (Figs. 2 c and d. Figs. 1 c and d).

Description of one normal and three fused incisor buds in 15 day-old mouse embryos on the basis of wax plate reconstructions

Incisor buds, as well as the part of the oral epithelium lying opposite the germs, are shown in the models and included in the description.

Normal mouse embryo (Figs. 5, 6, 13 and 17).

The oral epithelium forms a trapezial plate with its base posteriorly. The *oral (inferior) surface* as a whole is concave. The posterior two thirds of the surface are without relief, whilst the anterior third has a median rounded elevation, separated on each side by a weak groove from a low lateral crest.

The *basal surface* of the epithelial plate, corresponding to the junction between epithelium and connective tissue, as a whole is slightly convex (Fig. 13). Between the two buds is an anterior broad groove which is replaced closely to the centre of the plate by a smooth triangular area, which continues posteriorly between the buds. Laterally to each bud is a weak longitudinal groove.

The *tooth buds* are broad labio-lingual (antero-posterior) crests with an apically (upward) and distally free edge (Figs. 5 and 6). The edge has a saddle-shaped depression in the middle and labial and lingual prominences. The *labial end* or surface of the crest is flat and continues into a short and narrow incisal (inferior) free surface, while the lingual end continues to the oral epithelium and forms a right-angle with its basal surface. The distance between the two buds is almost twice as great lingually as labially.

Fusio dentium (Figs. 7—12, 14—16 and 18—20).

Collective description of the oral epithelium in the three forms of fusio

The oral epithelium forms a trapezial plate with a posterior base. The surface relief is not pronounced and differs only slightly from the relief in the normal embryo at the same stage.

The *oral surface* is concave, and its anterior half has a wide

median gentle elevation which is most pronounced in *fusio partialis and totalis*.

The *basal surface* is convex and a considerable proportion is covered by the bud (Figs. 14, 15 and 16). In front of the bud is a transverse shallow groove, and behind it a median rounded short prominence, absent in *fusio totalis* only.

Incisor buds

In *fusio partialis and subtotalis*, the tooth bud is a transverse elevation, the labial portion of which forms a prominent projection some distance from the oral epithelium (Figs. 7 and 9). The most important difference between the two buds is found on the *labial surface*: In *fusio partialis* it is divided into two oval areas by a vertical, narrow, median groove, which is lacking in *fusio subtotalis*. In both cases, the labial surface is separated from the incisal surface by a sharp edge.

The free part of the *incisal surface* is short and convex. The *lingual surface* extends from the apical (upper) edge of the labial surface to the oral epithelium (Figs. 8 and 10). It declines lingually and divides into two rounded crests, separated by a broad median depression. The labial (anterior) part of the surface is slightly convex.

Fusio totalis. The incisor bud forms a strong projection, which is widest lingually (Figs. 11 and 12). Its labial portion forms a prominence some distance from the oral epithelium. The *labial surface* is flat and separated from the incisal surface by an edge. The free part of the *incisal surface* is slightly convex and has considerable labio-lingual extent except in the mid-line, where the connection with the oral epithelium has a large labial extent.

The *lingual surface* extends from the apical (upper) edge of the labial surface to the oral epithelium. The surface is triangular with a lingual base. It is convex, and the labial (anterior) part is almost horizontal, whilst the rest declines strongly in a lingual direction. The surface is undivided.

DISCUSSION

The material used must be considered well suited for the study of morphological development of *fusio dentium*, as the epithelial part of the tooth buds is still at a primitive stage, and the de-

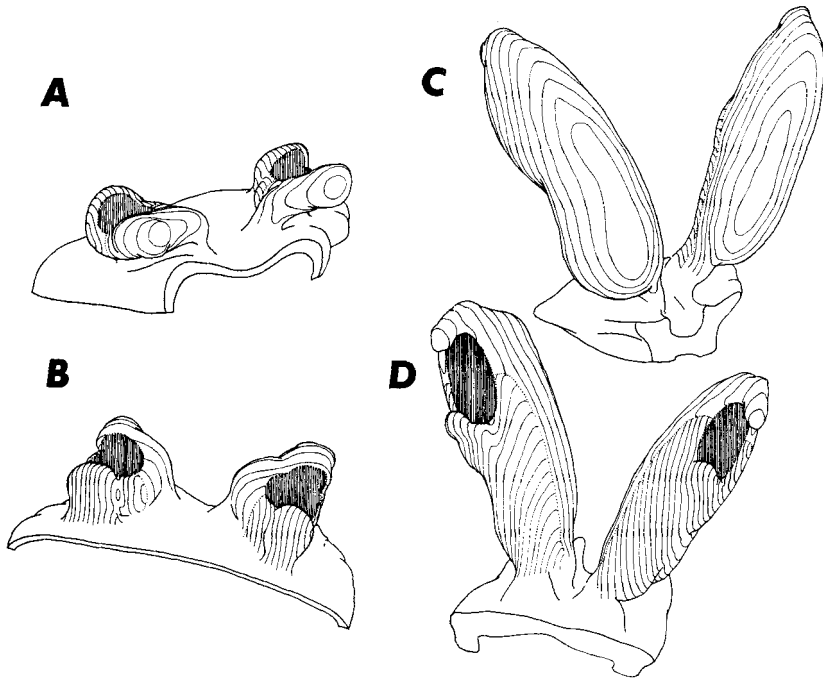


Fig. II. Diagram showing two stages of the development of normal upper incisor germs.

A and B: Upper incisor germs of a 15 day-old mouse embryo.

C and D: Upper incisor germs of a 19 day-old mouse embryo.

A and C: Labial view.

B and D: Lingual view.

velopment of the mesodermal portion of the germ has not yet begun. It is hardly likely that, apart from growth, there are any important morphological changes in the epithelium from the first thickening to the bud stage studied. The size of the buds in the embryos employed makes the histological examination easier and interpretation more certain; several of the results presented above would not emerge from an investigation at an earlier stage of development. With the object of studying the inductive role of the neural crest in tooth formation, it would, however, be of great interest to study even younger (13 days and less) exencephalic embryos with *fusio dentium*, on the same principles as those followed by *Pourtois* (1961 and 1964).

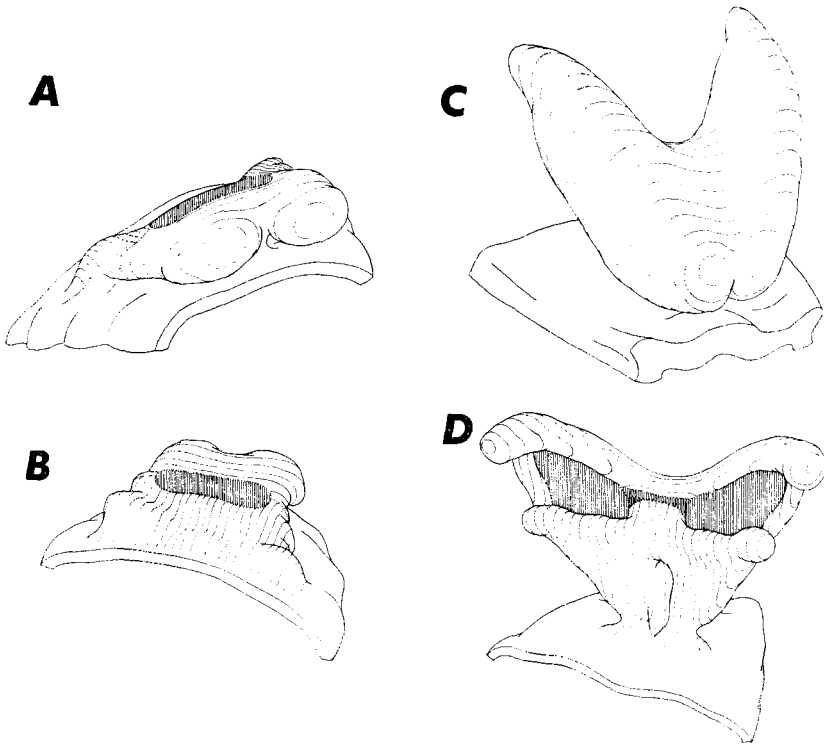


Fig. III. Diagram showing two stages of the development of fusio partialis. A and B: Upper incisor germ of a 15 day-old exencephalic mouse embryo. C and D: Upper incisor germ of a 19 day-old exencephalic mouse embryo. A and C: Labial view. B and D: Lingual view.

Study of the wax plate reconstructions confirms that the tooth germs examined are primitive. This becomes apparent in naming and describing the surfaces, since they cannot without difficulty be compared directly with the surfaces on models of germs from older embryos. The surface designations given in the present description of the incisor buds express as far as possible the direction of the surface on the model, without reference to its direction and name at a later stage. The labial surface and the labial part of the free edge in the young normal bud are assumed, for instance, to become the final labial surface (Text Fig. II). In the

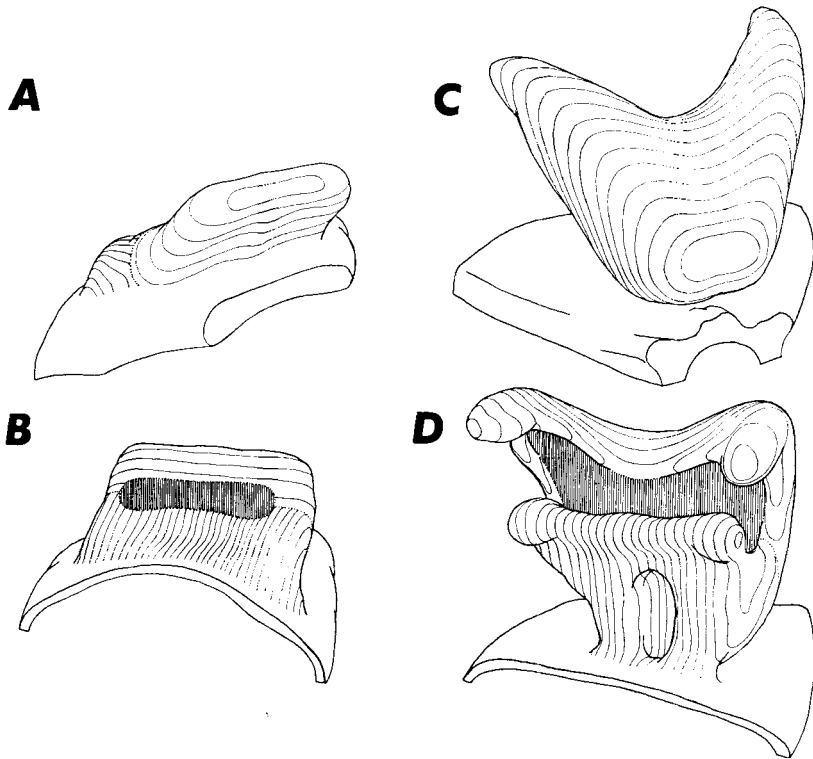


Fig. IV. Diagram showing two stages of the development of fusio subtotalis.
 A and B: Upper incisor germ of a 15 day-old exencephalic mouse embryo.
 C and D: Upper incisor germ of a 19 day-old exencephalic mouse embryo.
 A and C: Labial view.
 B and D: Lingual view.

three types of fusio dentium it is most likely that the definitive labial surface is developed from the labial surface of the bud, in connection with the labial (anterior) part of the so-called lingual surface, which on the model of fusio totalis is almost horizontal (Text Fig. V), whilst it declines lingually in the other two forms (Text Figs. III and IV). Complete understanding of all the morphological changes can, however, only be acquired by reconstructing some of the intermediate stages. This, in connection with studies of mitotic activity in the different parts of the bud, could show the relative growth of the various surfaces.

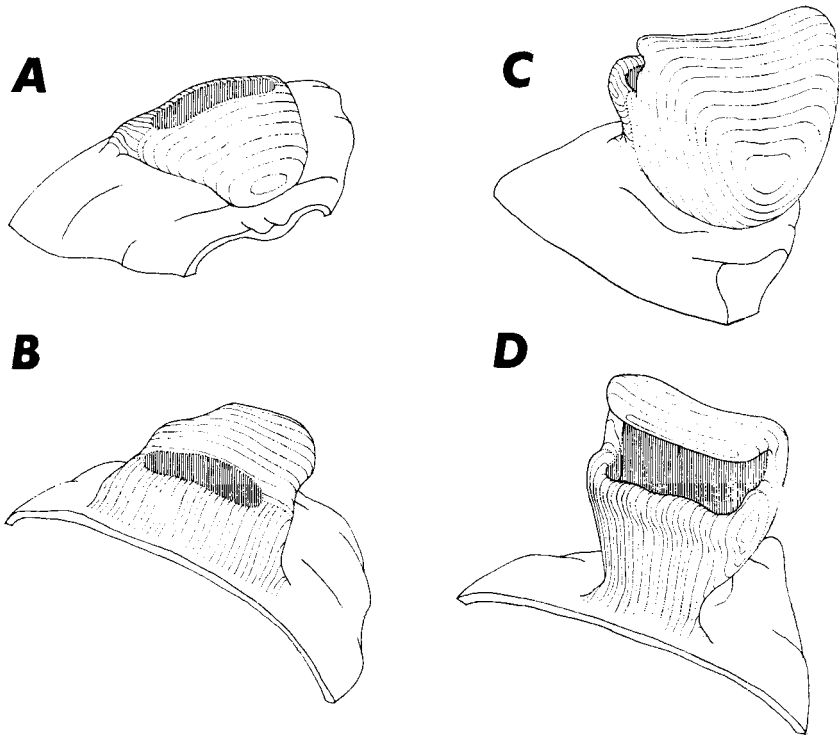


Fig. V. Diagram showing two stages of the development of fusio totalis. A and B: Upper incisor germ of a 15 day-old exencephalic mouse embryo. B and C: Upper incisor germ of a 18 day-old exencephalic mouse embryo. A and C: Labial view. B and D: Lingual view.

The oral epithelium becomes thicker as it develops and a characteristic surface relief is evolved. As shown on models in an earlier study of more mature embryos, it is in particular the relief of the *basal surface* which is developed both in fusio dentium and normal embryos. The *oral surface*, on the other hand, remains smooth and thereby retains a primitive character in fusio dentium. In normal embryos a distinct relief is developed.

The transition of the germs from bud to cap stage is difficult to determine accurately on histological sections. In this study, the emphasis in evaluation of the stage of development is placed on the external shape of the germ without reference to the de-

gree of histodifferentiation. In those cases where the contour is rounded or slightly flattened, the term 'bud stage' is used. This is the case in all 15 day-old embryos. When a distinct concavity arises on the germ surface in frontal sections, the term 'cap stage' is used. This is the case in most of the 16 day-old embryos.

As stated in the earlier study of older embryos, the expression *fusio dentium* refers exclusively to the appearance of the incisor germ at the end of prenatal life, without reference to the cause or mechanism of development. The present study shows that no fusion takes place during the investigated stages of the development, but that apparently right from the start a single germ is formed, ingrowth of epithelium in the mesenchyme only occurring at one place instead of the normal two places. The outline of the area where epithelial proliferation takes place differs according to the type of *fusio dentium* (Figs. 14, 15 and 16).

The investigation further shows that it can be decided as early as the bud stage whether *fusio dentium* or two separate germs will develop. In 15 day-old embryos it is possible to determine with certainty whether *fusio totalis* or *fusio subtotalis* will develop. There is uncertainty regarding *fusio partialis*, but undoubtedly application of the criteria mentioned considerably reduces the uncertainty.

The definition of *fusio dentium* established through study of older embryos presupposes that all the layers in the enamel organ, as well as dentine and pulp with odontoblasts, cross the mid-line. The extent to which this occurs in an antero-posterior (labio-lingual) direction, determines whether the term *fusio totalis*, *subtotalis* or *partialis* is to be applied. The considerable resemblance between an early stage of *fusio partialis* and an early stage of germs where the only connection is between the incisal parts of the enamel organs may speak for extending the *fusio dentium* conception to the latter, which, at a later stage, can be considered a single, strongly cleft incisor germ. This possibility has been mentioned earlier, without knowledge of the primitive stages. The considerable similarity which has now been demonstrated between bud stages makes the problem a real one. It would, however, be unfortunate to alter the earlier definition of *fusio dentium*, as this has proved very useful in study of ma-

ture embryos. A practical solution would be to introduce the conception *fusio epithelialis*, thereby retaining the original definition and terms employed for the various degrees of fusio dentium, emphasizing the developmental similarity, and at the same time indicating that the connection across the mid-line consists of epithelium only.

This study does not answer the question of the cause of fusio dentium in exencephalic embryos, but it shows that the process leading to fusio dentium begins early, and that the evolution of the germs follows a predetermined morphological plan, which is unlikely to be changed during development. This investigation thus supports the more important conclusions reached on the basis of the detailed morphological study of fusio dentium in older embryos.

SUMMARY

Histological studies were made of serial sections of 15—16 day-old mouse embryos with exencephaly induced by vitamin A overdose. The object was to decide whether it is possible to recognize as early as the bud stage the three degrees of fusion of the incisor germs in the upper jaw which have been demonstrated in 51 % of older exencephalic embryos. It emerged that fusio totalis and subtotalis can be identified without difficulty at the bud stage, whilst fusio partialis can be confused with a form which it is suggested be called fusio epithelialis, having a connection only between the incisal parts of the enamel organs of otherwise separate incisor germs. Criteria have been established for more certain identification of the two forms. The investigation shows that there is no fusion during the development of fusio dentium, but that apparently right from the beginning only one germ is formed, epithelial ingrowth into the mesenchyme occurring at a single spot. The term fusio dentium thus refers to the appearance of the germ late in prenatal life and not to the developmental process itself.

On the basis of wax models a morphological description of the bud stage of a normal germ and a representative of each of the

three types of fusio dentium is given. Finally, the difficulties involved in a more detailed morphological comparison of the tooth buds with mature germs is discussed.

RÉSUMÉ

FUSION DES INCISIVES SUPÉRIEURES AU STADE DU BOURGEON OU AU STADE DE LA CUPULE DANS DES EMBRYONS DE SOURIS PRÉSENTANT UNE EXENCÉPHALIE PROVOQUÉE PAR HYPERVITAMINOSE A

Des études histologiques de coupes en série d'embryons de souris de 15—16 jours présentant une exencéphalie provoquée par surdosage de vitamine A ont été faites. Le but proposé était de décider s'il est possible de reconnaître dès le stade du bourgeon les trois degrés de fusion des germes d'incisives supérieures qui ont été mis en évidence chez 51 % des embryons exencéphaliques à un stade plus avancé. Il apparaît que la fusion totale et la fusion subtotale peuvent être identifiées sans difficulté au stade du bourgeon, tandis que la fusion partielle peut prêter à confusion avec une forme que l'auteur propose de nommer fusion épithéliale, où une liaison n'existe qu'au niveau des parties incisives des organes de l'émail de germes d'incisives séparés par ailleurs. Des critères ont été établis pour permettre une identification plus sûre de ces deux formes. Cette étude montre qu'il n'y a pas de fusion pendant le développement de la fusion dentaire, mais qu'il se forme apparemment dès le début un seul germe, la pénétration épithéliale dans le mésenchyme se produisant en un seul endroit. Le terme fusion dentaire se rapporte ainsi à l'apparence du germe à un stade avancé de la vie prénatale, et non au mode de développement lui-même.

En se basant sur des modèles de cire, l'auteur donne une description morphologique du stade du bourgeon d'un germe normal et d'un exemple de chacun des trois types de fusion dentaire. Enfin l'auteur discute les difficultés soulevées par une comparaison morphologique plus détaillée des bourgeons dentaires avec les germes à maturité.

ZUSAMMENFASSUNG

VERSCHMELZUNG DER OBEREN SCHNEIDEZÄHNE IN KNOSPEN- UND KAPPENSTADIEN BEI MÄUSEEMBRYONEN MIT EXENCEPHALIE. DIE DURCH ÜBERDOSIERUNG MIT VITAMIN A HERVORGERUFEN IST

Histologische Untersuchungen wurden ausgeführt an Serienschnitten von 15—16 Tage alten Mäuseembryonen mit Exencephalie, hervorgerufen durch Überdosierung mit Vitamin A. Der Zweck war zu entscheiden, ob es schon in dem Knospenstadium möglich ist, die drei Formen der Verschmelzung der Schneidezahnanlagen des Oberkiefers, die in ca. 51 % der älteren exencephalen Embryonen nachgewiesen wurden, zu erkennen. Es zeigt sich, dass fusio totalis und subtotalis sich ohne Schwierigkeit in dem Knospenstadium identifizieren lassen, während fusio partialis mit einer Form verwechselt werden kann, die man nach unserem Vorschlag fusio epithelialis benennen konnte, und die aus einer Verbindung allein zwischen den incisalen Teilen der Schmelzorgane der übrigens getrennten Schneidezahnanlagen besteht. Es werden Kriterien aufgestellt um mit grösserer Sicherheit die zwei Formen zu identifizieren. Die Untersuchung zeigt, dass während der Entwicklung von fusio dentium kein Verschmelzungsprozess vor sich geht, dass aber vom Anfang an nur eine einzelne Zahnanlage gebildet wird, indem Epitheleinwuchs in das Mesenchym an einer einzelnen Stelle vorkommt. Die Bezeichnung fusio dentium bezieht sich so auf das Aussehen der Zahnanlage am Schluss des embryonalen Lebens und nicht auf den Entwicklungsmechanismus.

Auf Grund der Wachsrekonstruktionen gibt man eine morphologische Beschreibung der Knospenstadien einer normalen Schneidezahnanlage und eine entsprechende Beschreibung eines Vertreters jeder der drei Formen von fusio dentium. Schliesslich werden die Schwierigkeiten erörtert, die mit einem morphologischen Vergleich der primitiven Anlagen mit den Zahnanlagen in älteren Embryonen verbunden sind.

REFERENCES

- Knudsen, P. A.*, 1965: Congenital malformations of upper incisors in exencephalic mouse embryos induced by hypervitaminosis A. I. Types and frequency. *Acta odont. scand.* 23: 71—89.
- »— 1965: Congenital malformations of upper incisors in exencephalic mouse embryos, induced by hypervitaminosis A. II. Morphology of fused upper incisors. *Acta odont. scand.* 23: 391—409.
- Monat, H. Z.*, 1955: Demonstration of all connective tissue elements in a single section. *Arch. Path.* 60: 289—295.
- Pourtois, M.*, 1961: Contribution à l'étude des Bourgeons dentaires chez la Souris. I. Périodes d'Induction et de Morphodifférenciation. *Arch. Biol. (Liège)* 72 (1): 17—95.
- »— 1964: Comportement en culture in vitro des ébauches dentaires de rongeurs prélevées aux stades de prédifférenciation. *J. Embryol. exp. Morph.* 12: 391—405.

Address: *Aarhus Tandlægehøjskole*
Vennelyst Boulevard
Aarhus C, Denmark

PLATES

List of abbreviations

- A = apical end.
- C = crest (elevation).
- I = incisal end.
- L = labial surface.
- LI = lingual surface.
- S = sulcus (depression).
- TR = tooth germ removed.

Plate 1.

Fig. 1. Exencephalic mouse embryo (202 d I 2), 15 days.

FUSIO EPITHELIALIS.

(This term indicates that, in later stages, there will only be a connection between the incisal ends of the enamel organs of the upper incisor germs).

Upper incisor germs. *Arrow:* low magnification ($\times 25$). *a-e:* higher magnification ($\times 160$). Frontal sections, starting at the labial (anterior) end of the germs.

Fig. 1 a: Considerable distance between the labial (anterior) parts of the two tooth germs. They are both separated from the oral epithelium.

Fig. 1 b: The tooth germs have approached the mid-line. They are still completely surrounded by mesenchyme.

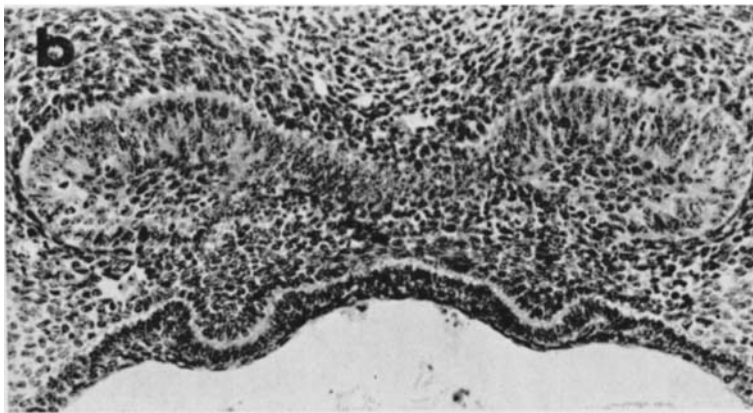
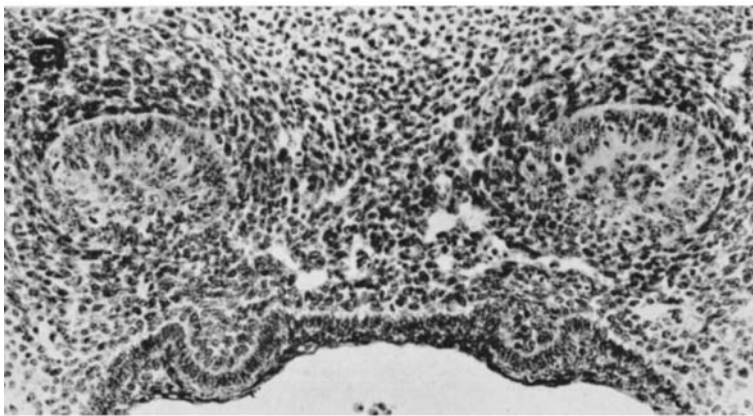


Plate 2.

Fig. 1 (continued).

Fig. 1 c: Connection between the tooth germs across the mid-line and between the tooth germs and the oral epithelium. The epithelial bridge crossing the mid-line is rather low.

Fig. 1 d: The connection with the oral epithelium is broad.

Fig. 1 e: Considerable distance between the lingual (posterior) parts of the two germs.

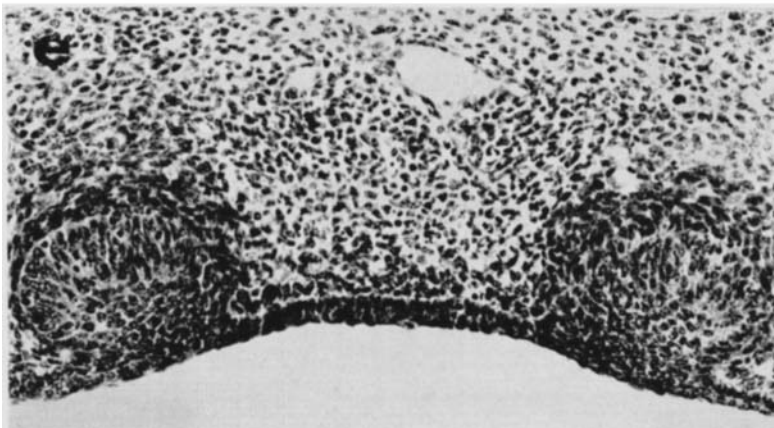
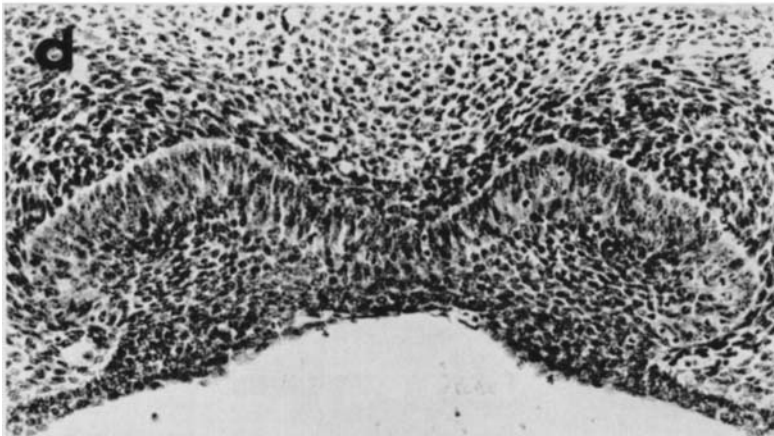
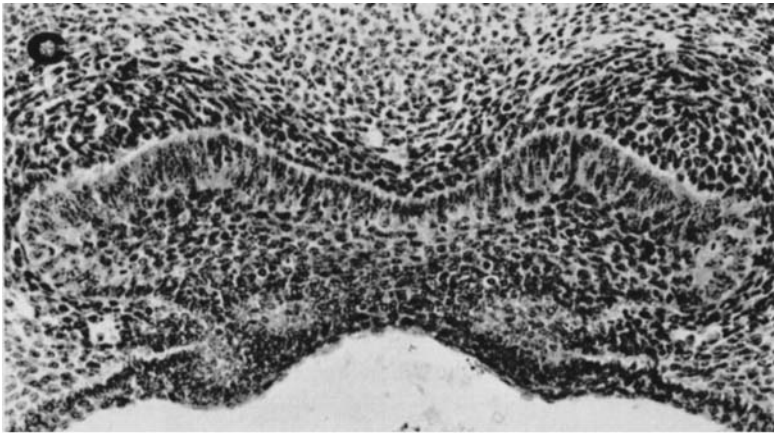


Plate 3.

Fig. 2. Exencephalic mouse embryo (229 d I 2) 15 days.

FUSIO PARTIALIS.

Upper incisor germ. *Arrow:* low magnification ($\times 25$). *a-e:* higher magnification ($\times 160$). Frontal sections, starting at the labial (anterior) end of the germ.

Fig. 2 a: The labial (anterior) part of the germ appears as two distinctly separate cell accumulations. The distance between them is shorter than in Fig. 1 a.

Fig. 2 b: The labial (anterior) part of the fused portion of the germ appears as a single broad cell accumulation crossing the mid-line. It is completely surrounded by mesenchyme and has no connection with the oral epithelium.

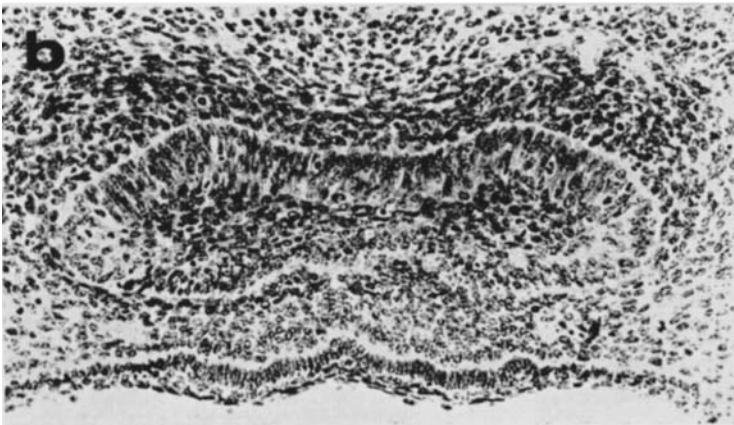
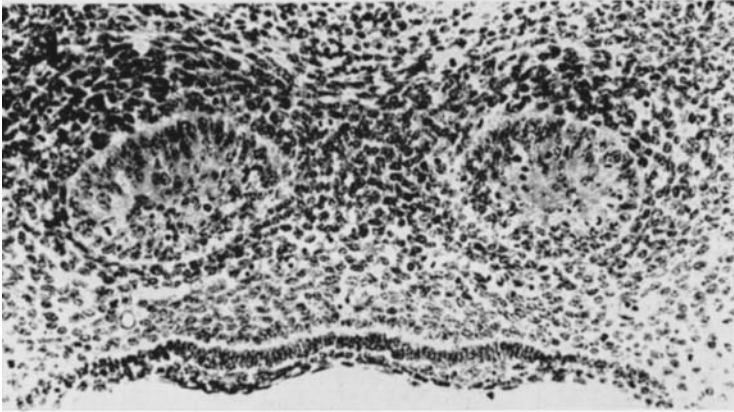
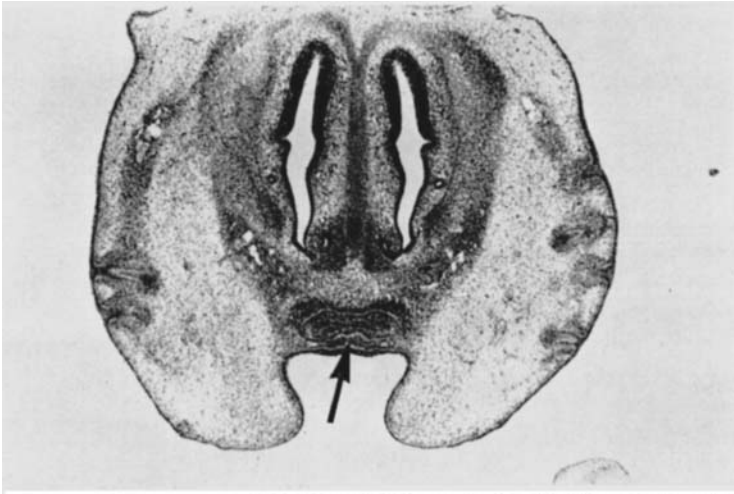


Plate 4.

Fig. 2 (continued).

Fig. 2 c: Connection between the tooth germ and the oral epithelium has been established. Along the mid-line the fused portion of the germ has almost the same height as the lateral portions.

Fig. 2 d: The stalk connecting the germ with the oral epithelium is narrower than the germ.

Fig. 2 e: The distance between the lingual (posterior) parts of the germ is shorter than in Fig. 1 e.

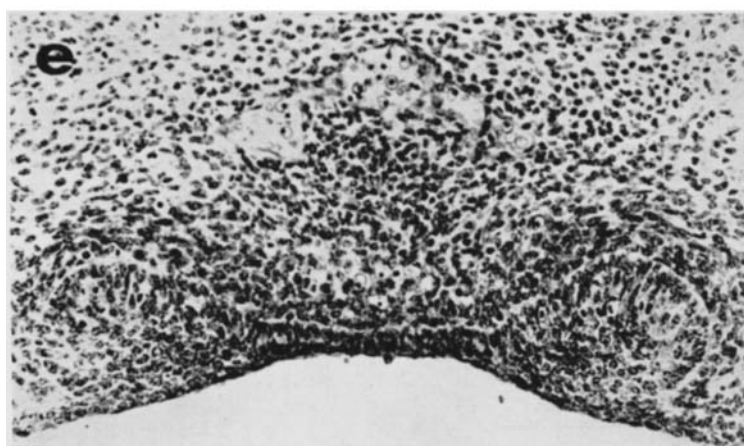
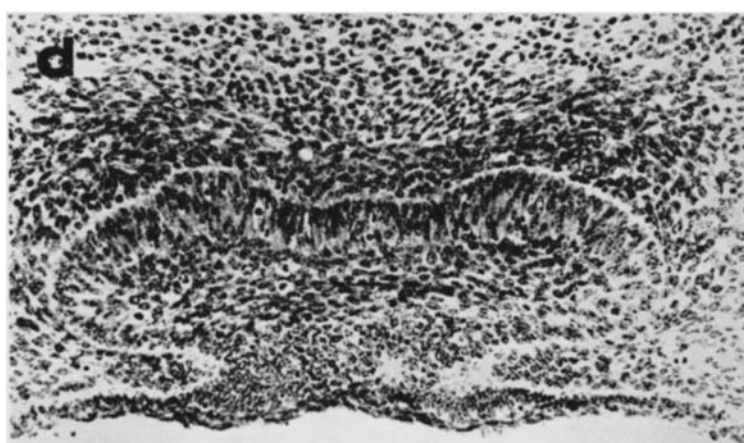
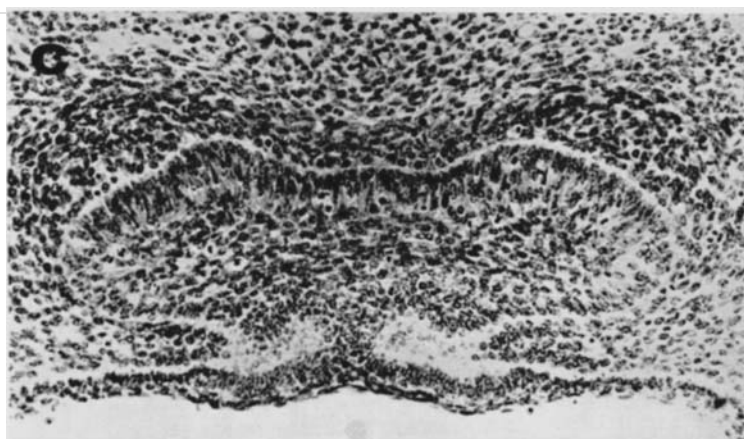


Plate 5.

Fig. 3. Exencephalic mouse embryo (226 d I 2), 15 days.

FUSIO SUBTOTALIS.

Upper incisor germ. *Arrow*: low magnification ($\times 25$). *a-e*: higher magnification ($\times 160$). Frontal sections, starting at the labial (anterior) end of the germ.

Fig. 3 a: The labial (anterior) end of the germ appears as one cell accumulation completely surrounded by mesenchyme.

Fig. 3 b: The germ is still separated from the oral epithelium.

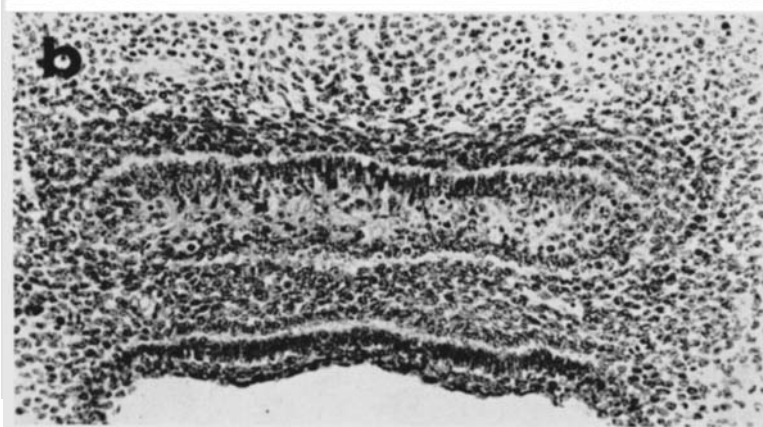
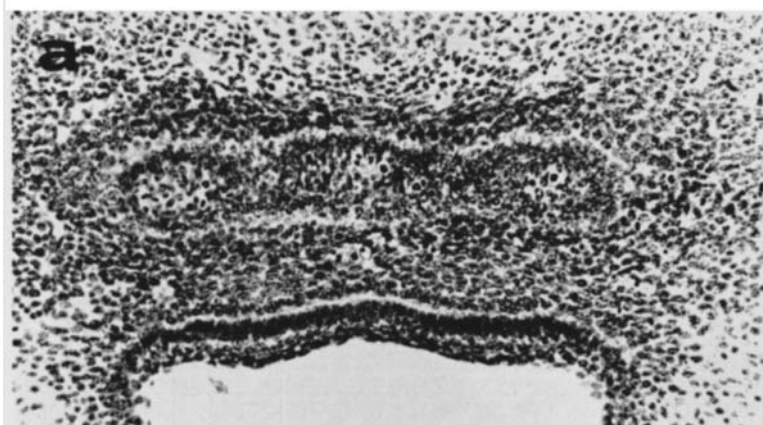


Plate 6.

Fig. 3 (continued).

Fig. 3 c: Narrow connection between the tooth germ and the oral epithelium.

Fig. 3 d: Incipient separation of the right and left parts of the germ.

Fig. 3 e: Considerable distance between the lingual (posterior) parts of the germ.

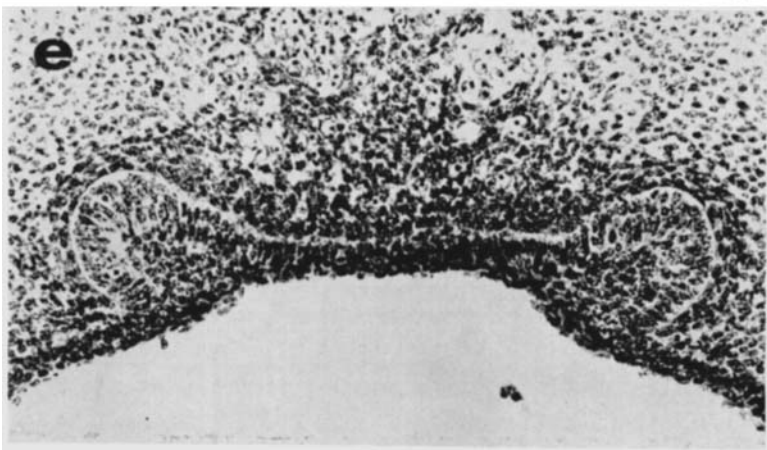
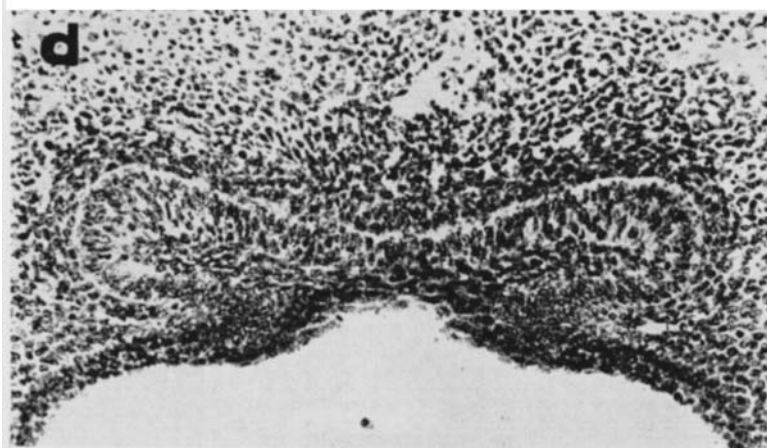
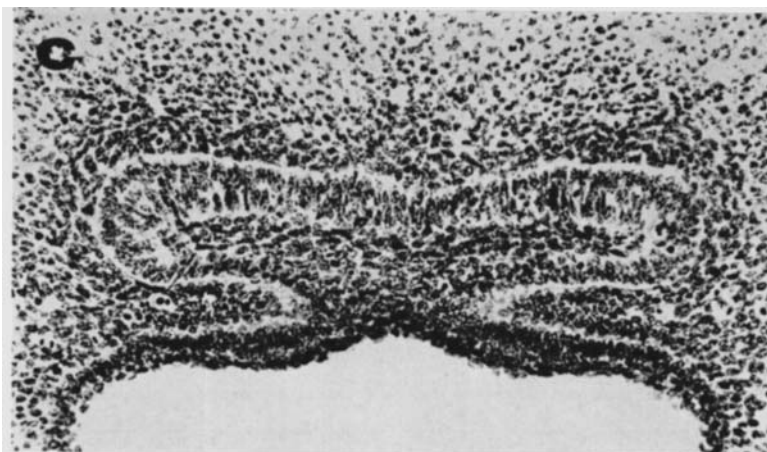


Plate 7.

Fig. 4. Exencephalic mouse embryo (228 d I 2), 15 days.

FUSIO TOTALIS.

Upper incisor germ. *Arrow:* low magnification ($\times 25$). *a-e:* higher magnification ($\times 160$). Frontal sections, starting at the labial (anterior) end of the germ.

Fig. 4 a: The labial (anterior) end of the germ appears as an oval cell accumulation completely surrounded by mesenchyme.

Fig. 4 b: The size of the germ is increasing and it is still separated from the oral epithelium.

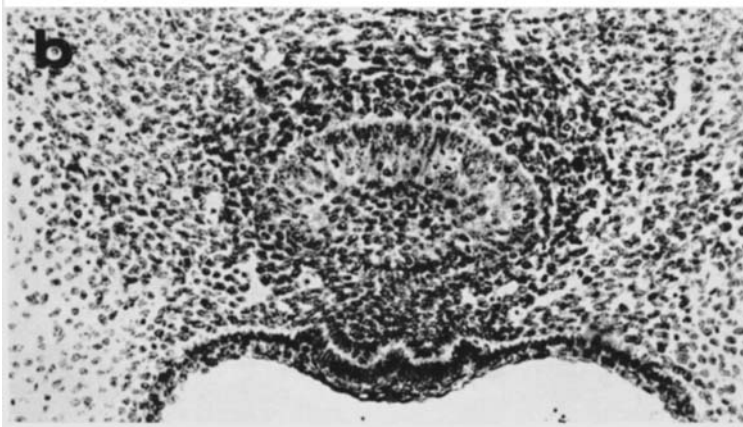
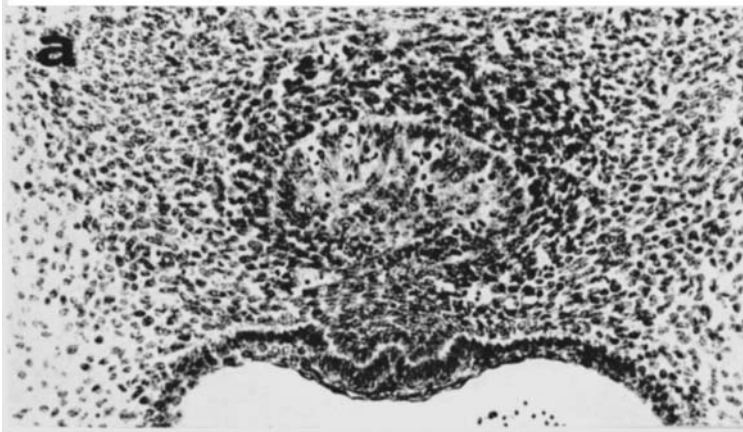
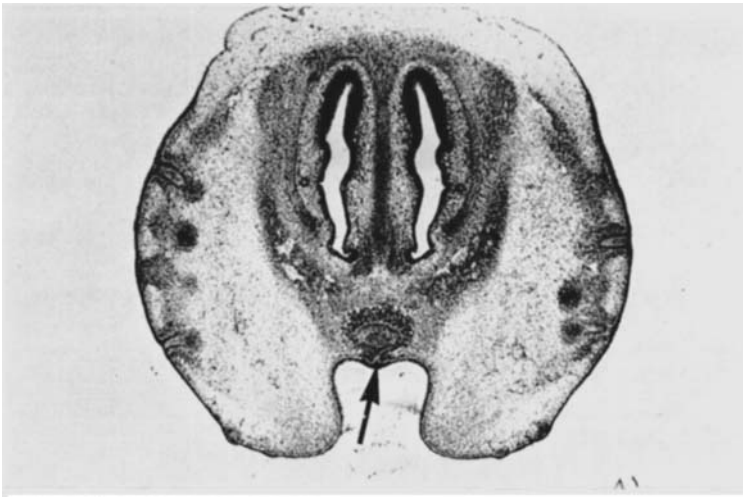


Plate 8.

Fig. 1 (continued)

Fig. 1 c: The connection between the germ and the oral epithelium appears as a narrow stalk.

Fig. 1 d: The connection with the oral epithelium is almost as wide as the germ.

Fig. 1 e: The lingual (posterior) end of the germ shows no sign of 'cleavage'.

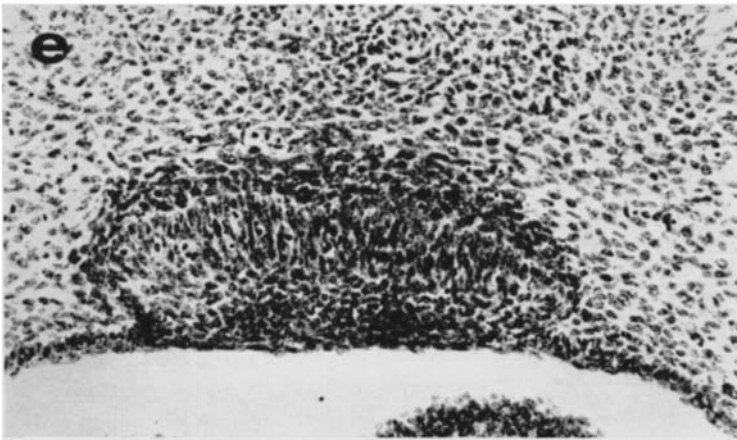
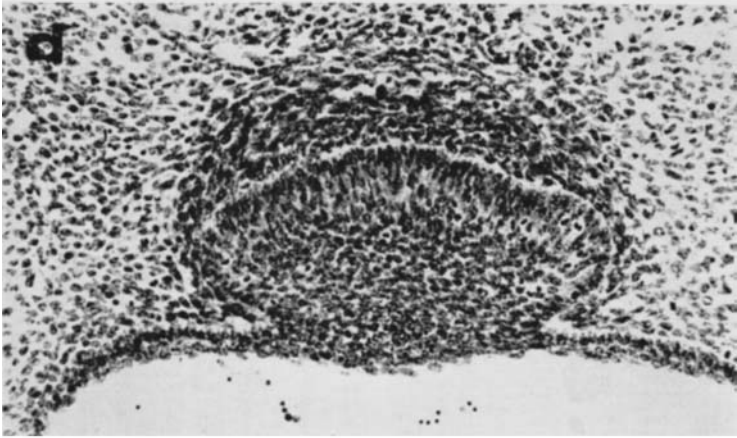
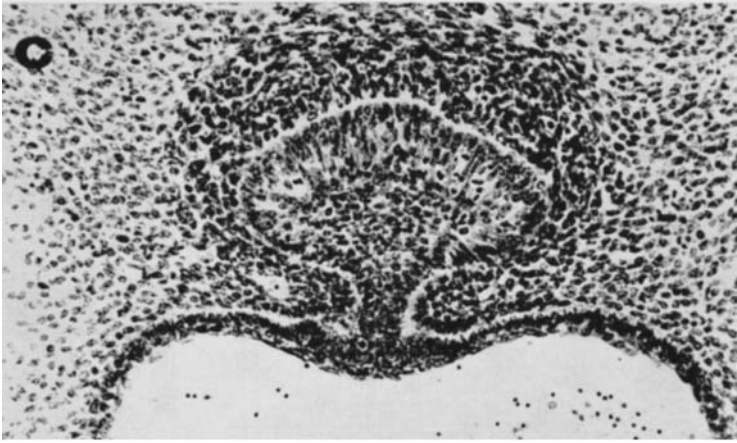


Plate 9.

Figs. 5-6. Normal mouse embryo, 15 days. Drawings of a model of the upper incisor germs and oral epithelium.

Fig. 5: Labial (and distal) view.

Fig. 6: Lingual view.

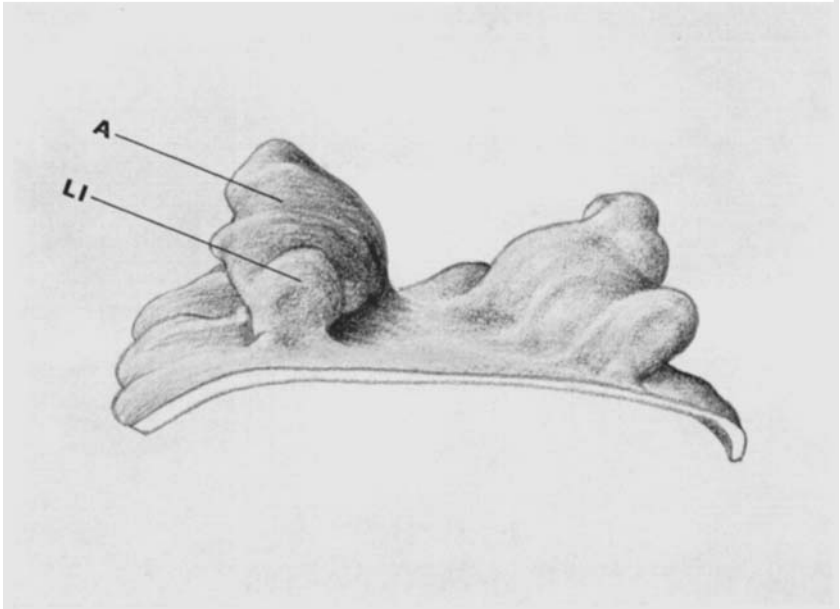
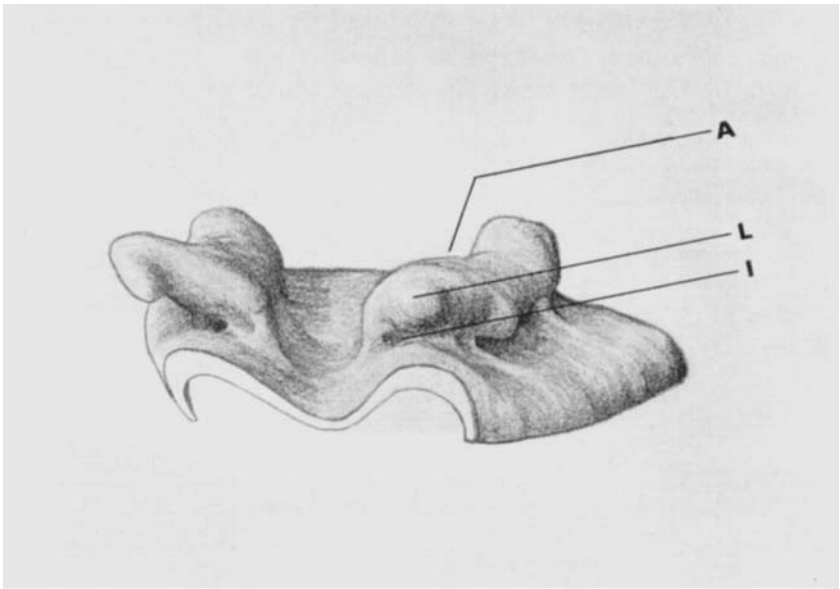


Plate 10.

Figs. 7-8. Exencephalic mouse embryo, 15 days.

FUSIO PARTIALIS.

Drawings of a model of the upper incisor germ and oral epithelium.

Fig. 7: Distal (and labial) view.

Fig. 8: Lingual view.

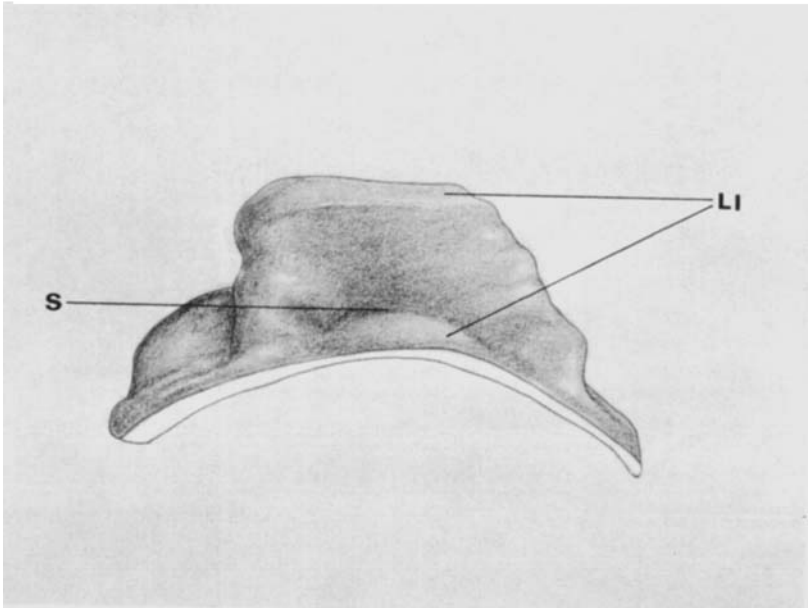
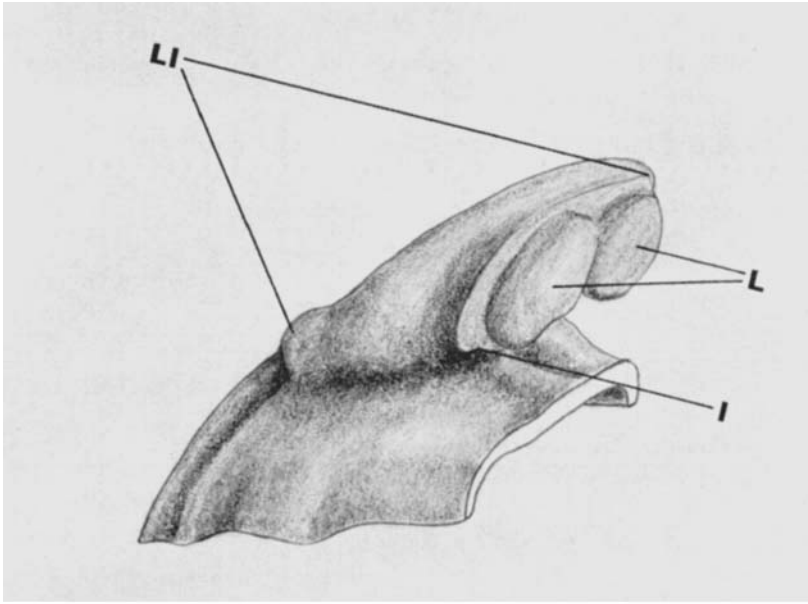


Plate 11.

Figs. 9-10. Exencephalic mouse embryo, 15 days.

FUSIO SUBTOTALIS.

Drawings of a model of the upper incisor germ and oral epithelium.

Fig. 9: Distal (and labial) view.

Fig. 10: Lingual view.

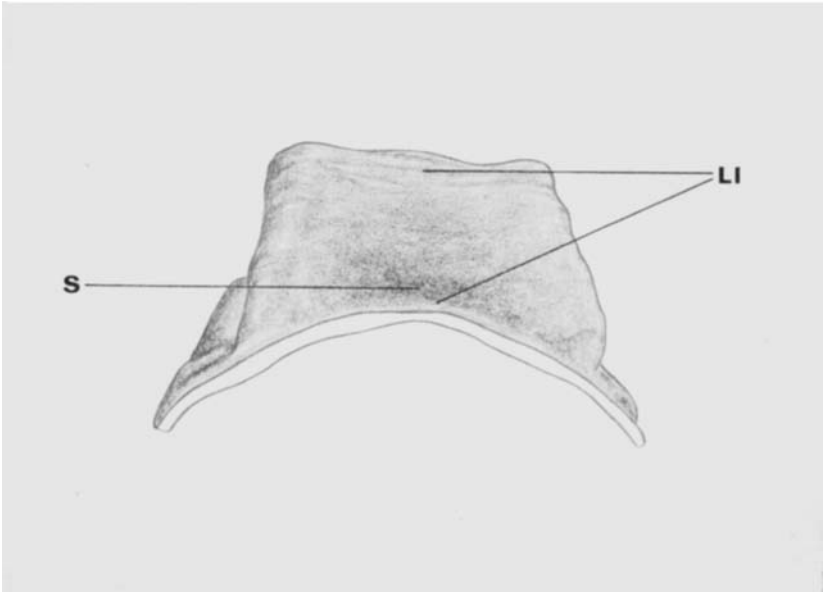
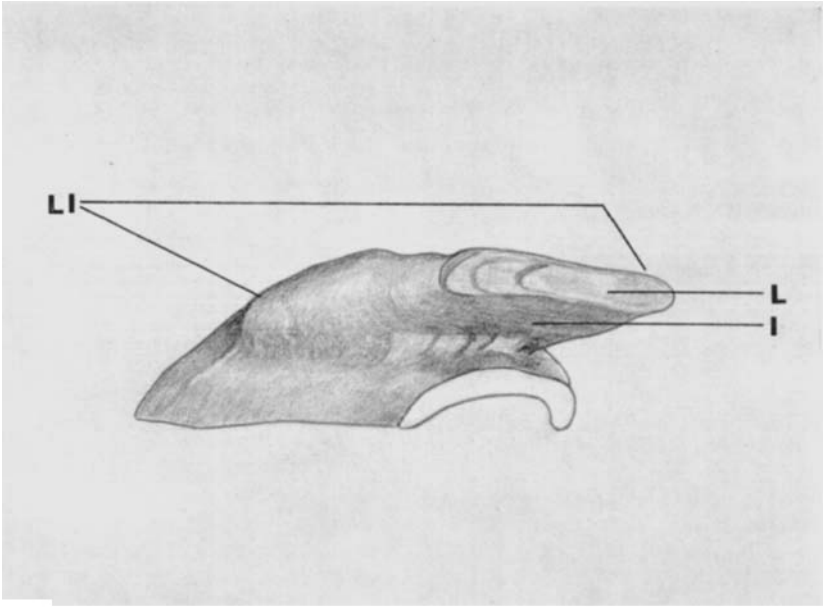


Plate 12.

Figs. 11 12. Exencephalic mouse embryo, 15 days.

FUSIO TOTALIS.

Drawings of a model of the upper incisor germ and oral epithelium.

Fig. 11: Distal (and labial) view.

Fig. 12: Lingual view.

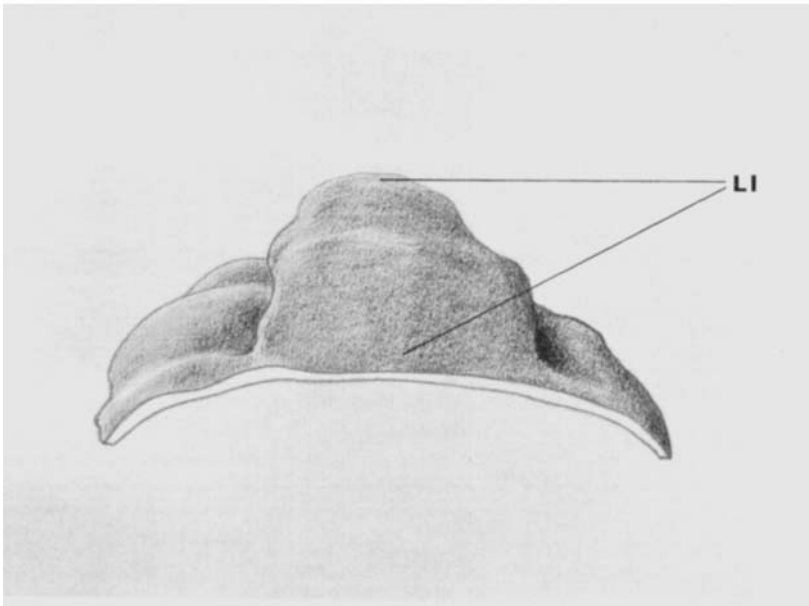
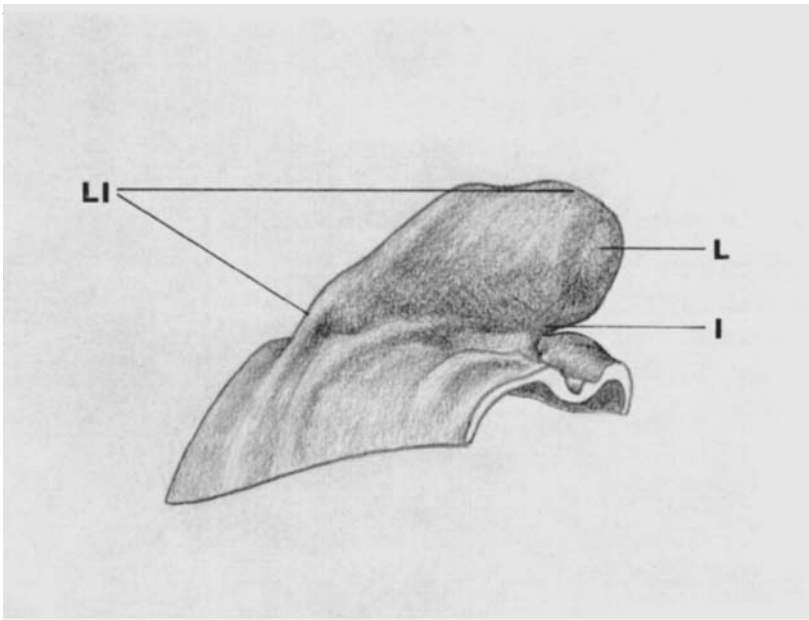


Plate 13.

Figs. 13 14. Drawings of the oral epithelium shown in Figs. 5 6 and 7-8. Basal view. The incisor germ has been removed along its connection with the epithelium.

Fig. 13: Normal mouse embryo.

Fig. 14: Exencephalic mouse embryo.

FUSIO PARTIALIS.

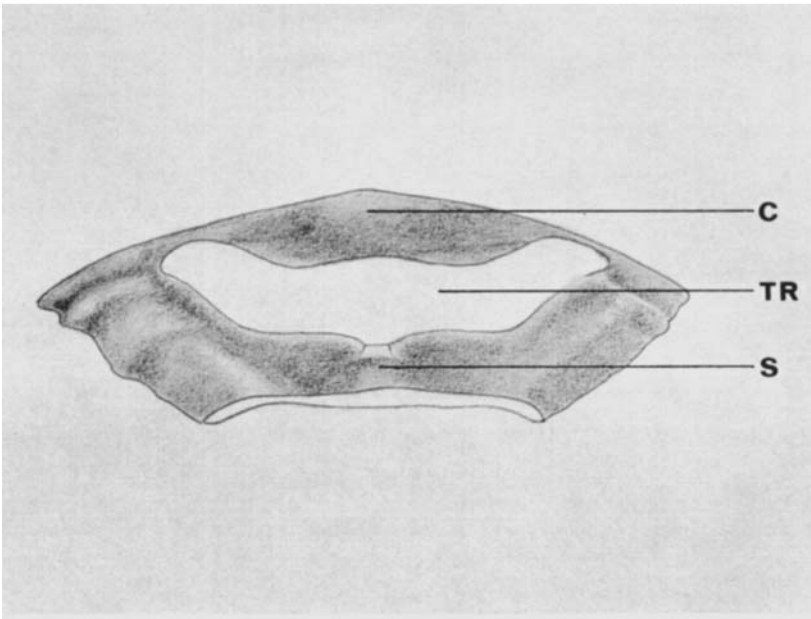
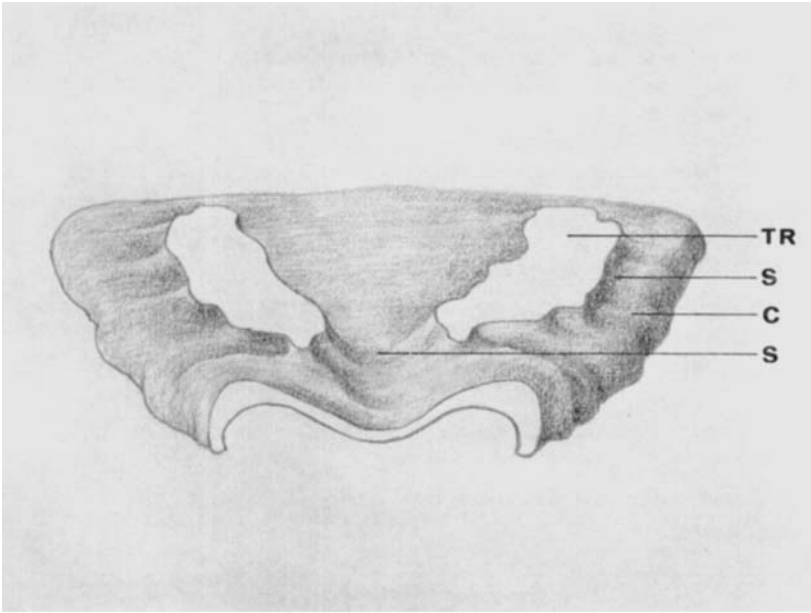


Plate 14.

Figs. 15-16. Drawings of the oral epithelium shown in Figs. 9-10 and 11-12. Basal view. The incisor germ has been removed along its connection with the epithelium.

Fig. 15: Exencephalic mouse embryo.

FUSIO SUBTOTALIS.

Fig. 16: Exencephalic mouse embryo.

FUSIO TOTALIS.

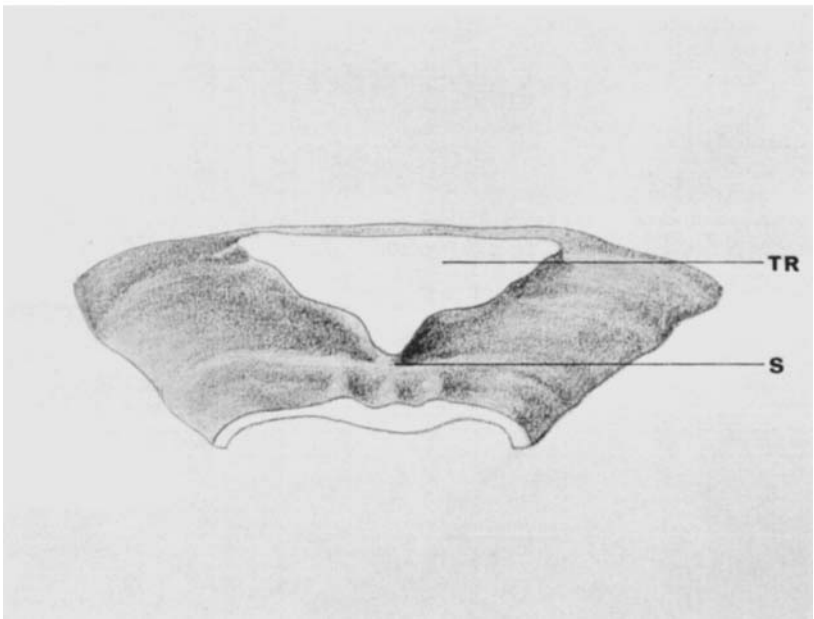
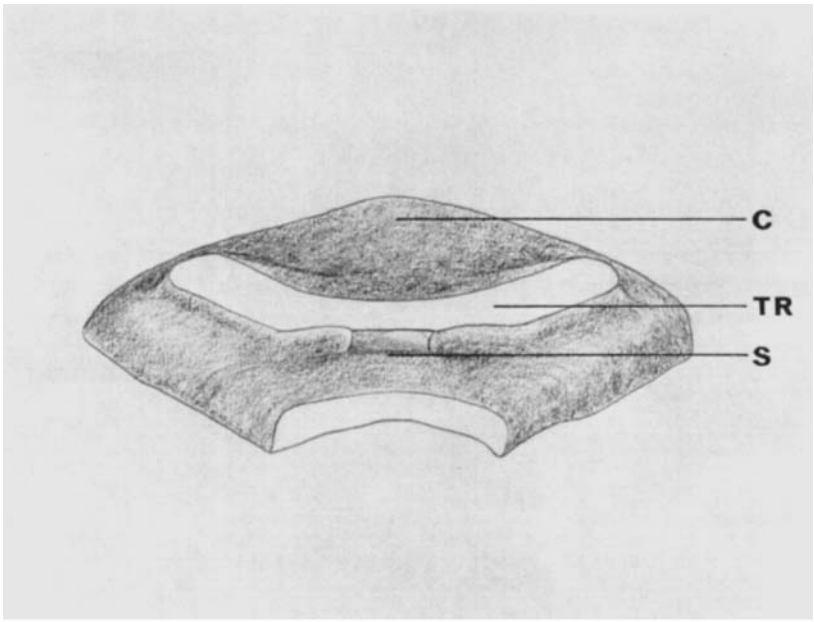


Plate 15.

Figs. 17-18. Photographs of wax plate reconstructions.

Fig. 17: Normal mouse embryo, 15 days (61 d VII 4). Upper incisor germs and oral epithelium; labial view.

Fig. 18: Exencephalic mouse embryo, 15 days (222 d 12).

FUSIO PARTIALIS.

Upper incisor germ and oral epithelium; labial view.

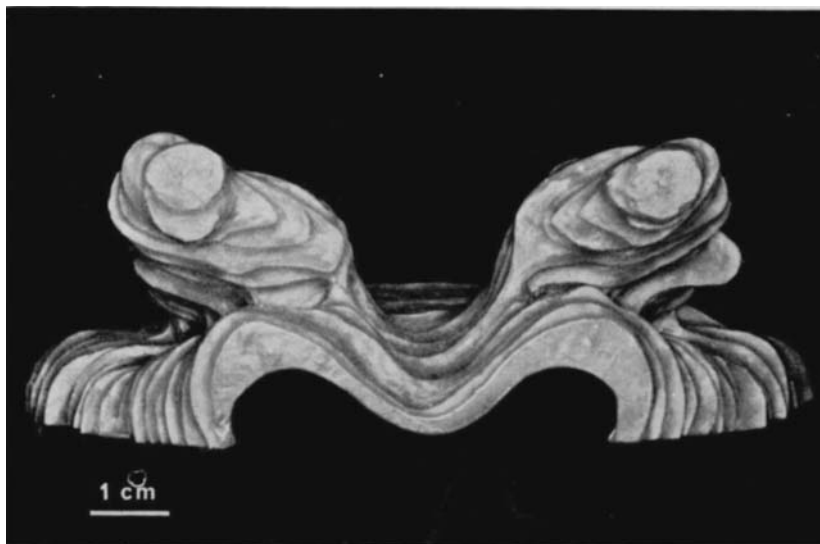


Plate 16.

Figs. 19-20. Photographs of wax plate reconstructions.

Fig. 19: Exencephalic mouse embryo, 15 days (226 d I 2).

FUSIO SUBTOTALIS.

Upper incisor germ and oral epithelium: labial view.

Fig. 20: Exencephalic mouse embryo, 15 days (228 d I 2).

FUSIO TOTALIS.

Upper incisor germ and oral epithelium: labial view.

