

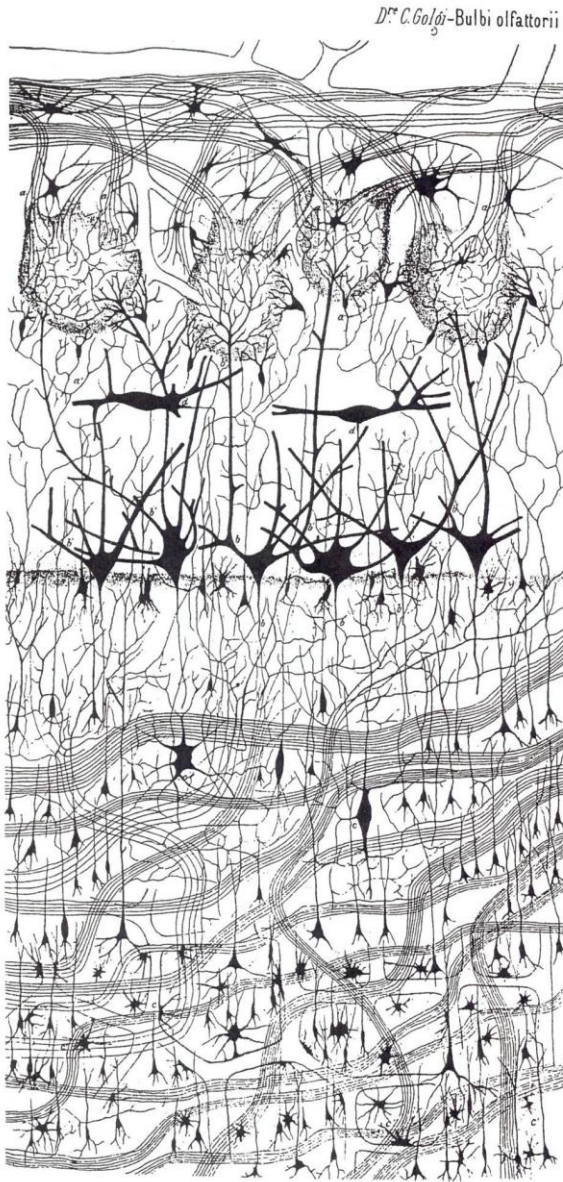
# Might the olfactory bulb be an origin of olfactory auras in focal epilepsy?\*

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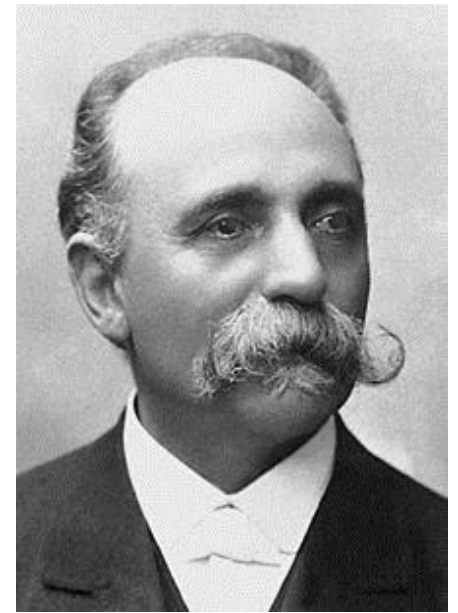
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Camera lucida drawing of the **human olfactory bulb**, by Camillo Golgi, 1876. **This was the first human brain structure published as a microscopic silver Golgi impregnation.**

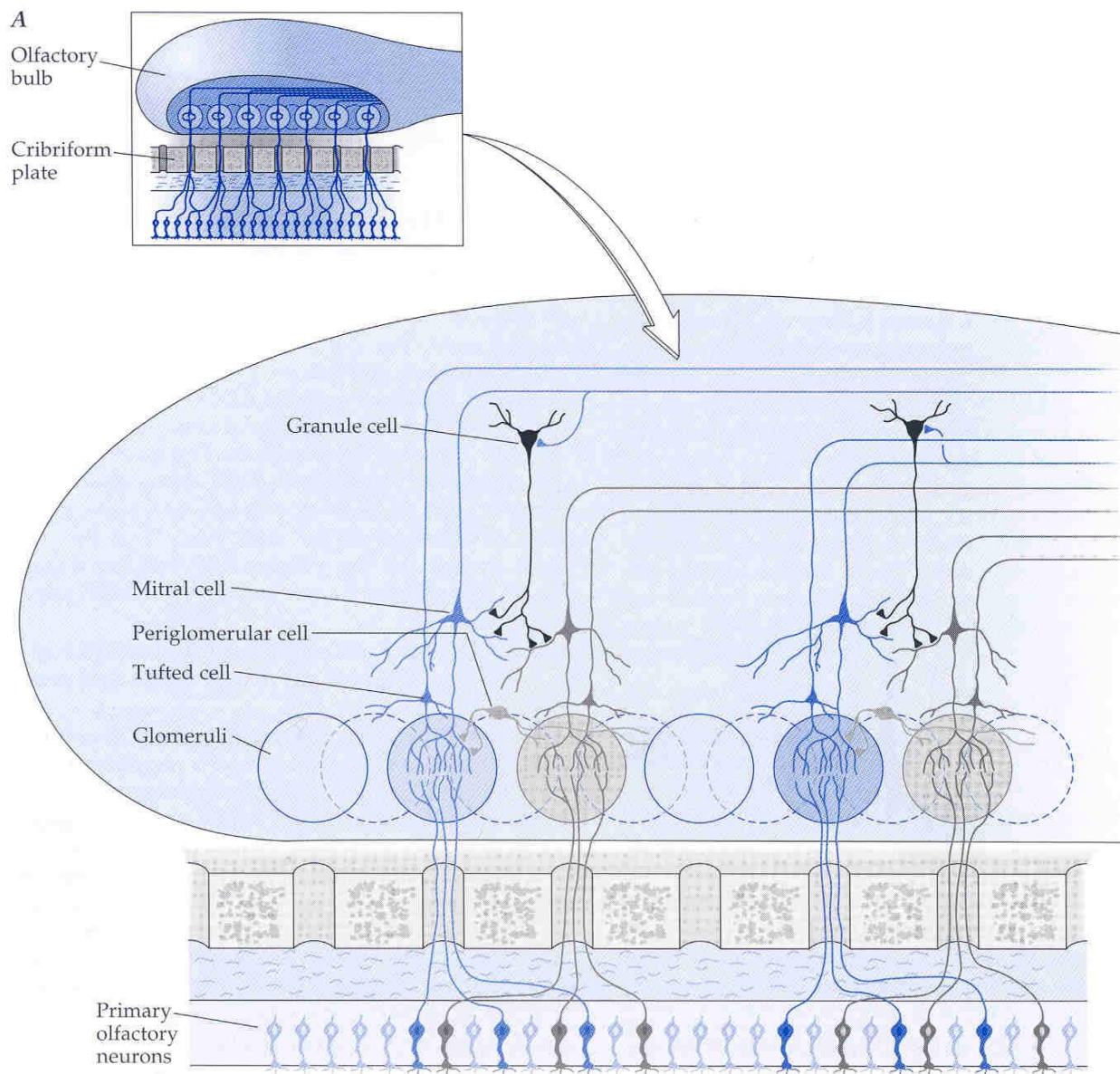


Golgi C. Sulla fina struttura dei bulbi olfactorii. Riv. sper. freniat. Reggio-Emilia. 1875; 1: 66-78.

**First descriptions of microscopic anatomy of the human olfactory bulb:**

Owsjannikow P. Über die feinere Struktur der Lobi olfactorii der Säugethiere. Müller Arch f. Anat Physiol und wissensch. Med. Leipzig. 1860. pp 469-477.

Walter C. Über den feineren Bau des Bulbus olfactorius. Virchow Arch f. pathol Anat und Physiol. Berlin. 1861; 22: 241-259.



The 6 layers of the olfactory bulb do not correspond to those of neocortex:

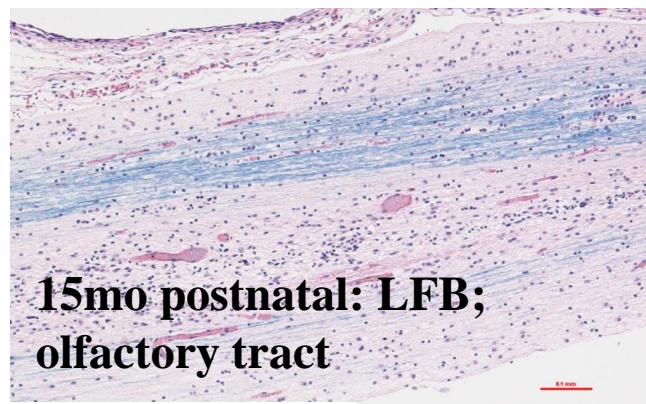
- 1) unmyelinated axons of primary receptor neurons;
- 2) synaptic glomeruli;
- 3) tufted neurons and external plexiform layer;
- 4) row of mitral cells
- 5) internal plexiform layer;
- 6) granular cell layer and progenitor cells;

Deep white matter origin of olfactory tract and progenitor cell processes.



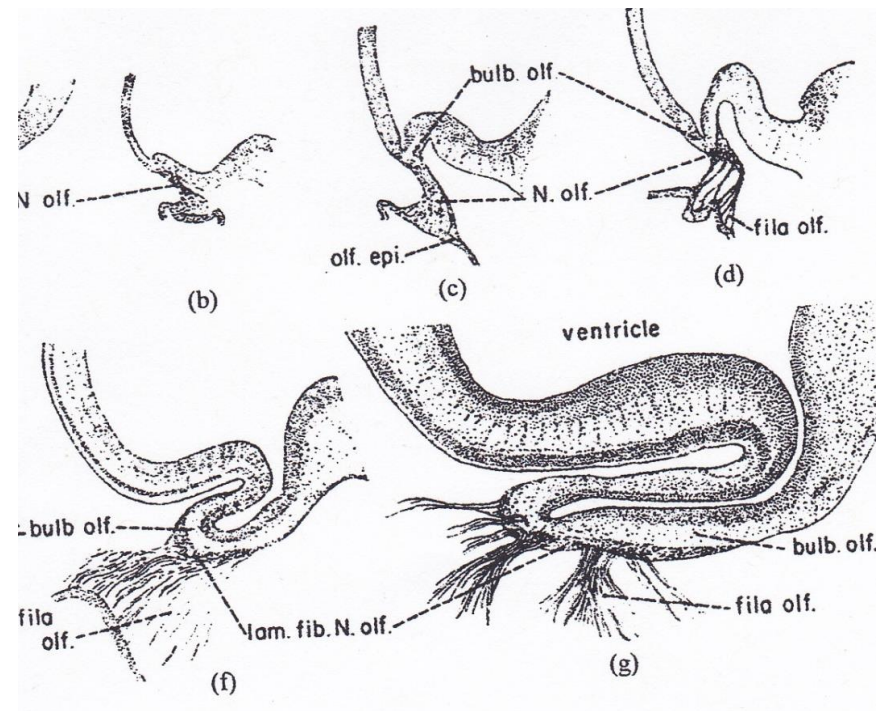
# Immaturity of the olfactory bulb and tract at term

**Myelination in the olfactory bulb and tract is a postnatal process.** Luxol fast blue (LFB) stain: no myelin at term.



**The olfactory ventricular recess is a transitory fetal diverticulum from the lateral ventricle that enlarges with the formation of the olfactory bulb, but then regresses postnatally; it is still present in the normal term neonate.**

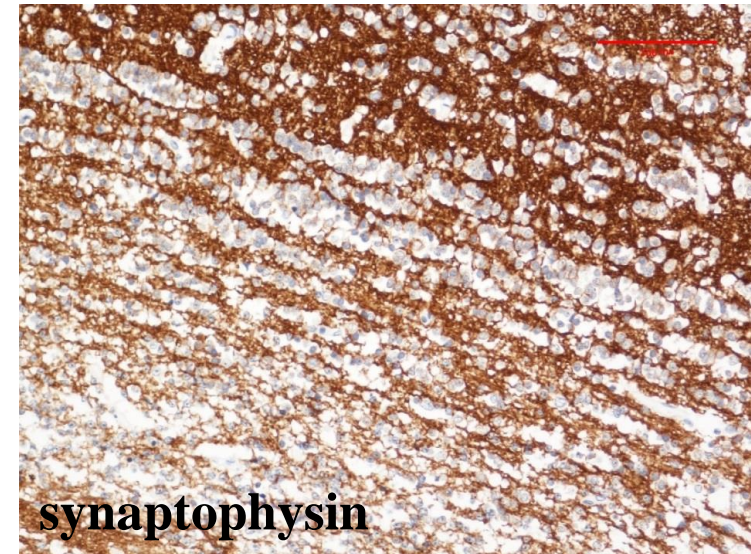
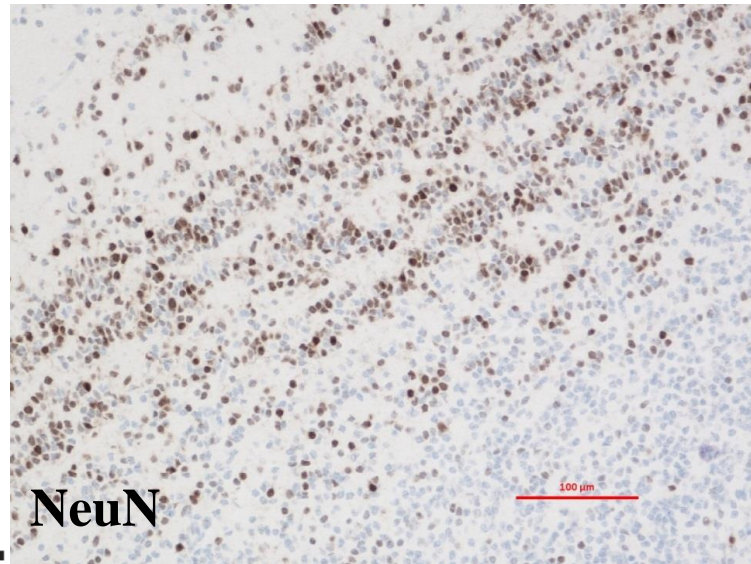
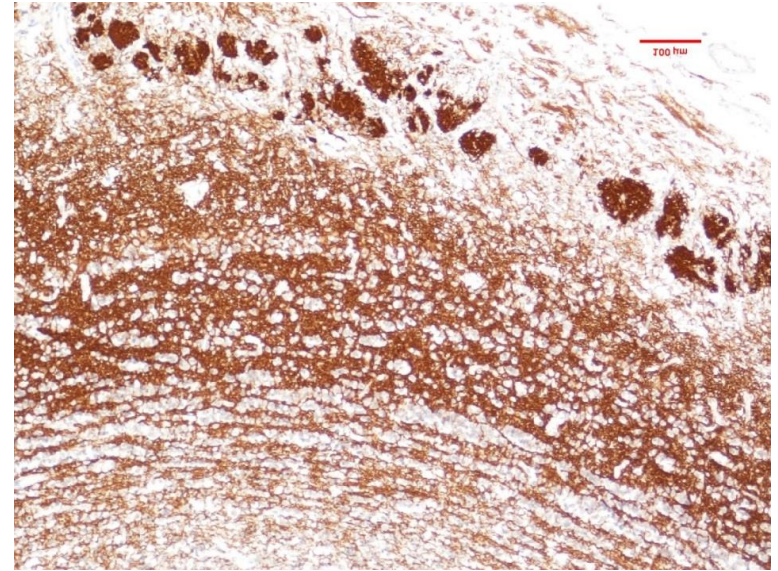
(below drawing from: Pearson A. *J Comp Neurol* 1941;75:199-217.)





## **Full-term neonate: immature granular neuronal core of the olfactory bulb**

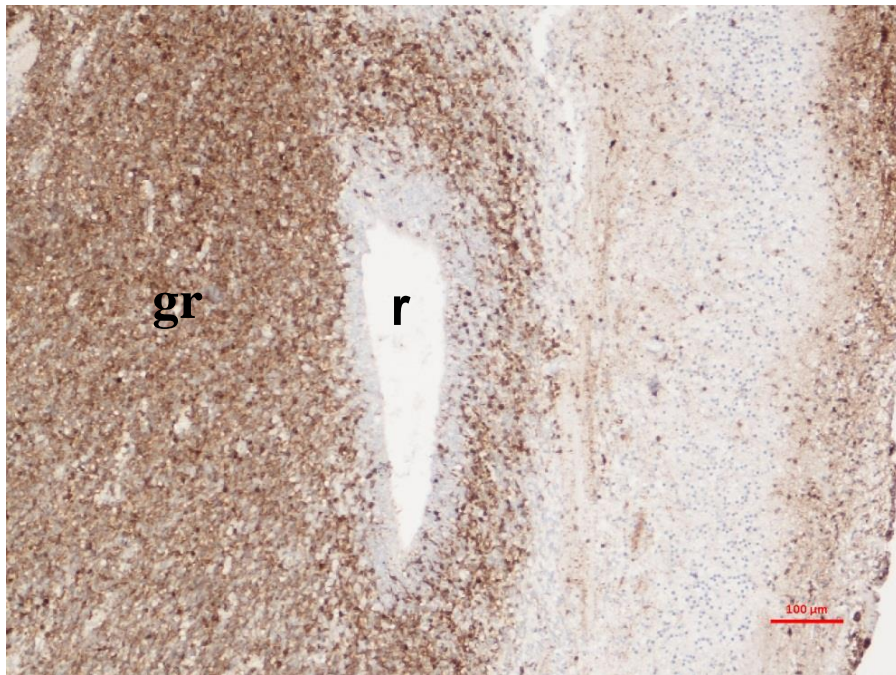
Multiple concentric layers, granular neurons (NeuN, a late neuronal maturational marker) alternate with dendro-dendritic synapses (synaptophysin), but not yet in the deep core where neuroblasts predominate. Synaptic glomeruli are intensely reactive at the surface. **The olfactory bulb at term birth exhibits immaturity of neuronal proteins (NeuN) and of synapse formation (synaptophysin).**



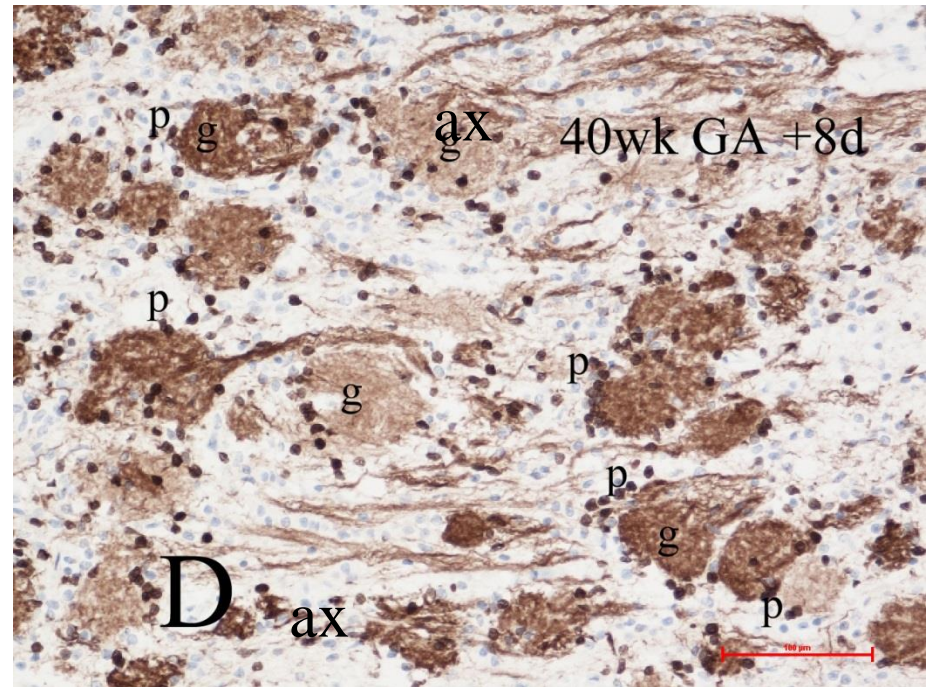


**Calretinin (early neuronal maturation marker) demonstrates early core granular cell reactivity before mid-gestation and shows immature synaptic glomeruli at term.**

**19wk gestation normal fetus:** Granular neurons (**gr**) in the core, surrounding the olfactory ventricular recess (**r**), are intensely reactive for calretinin, as GABAergic neuronal precursor cells that lack axons and form dendro-dendritic synapses.



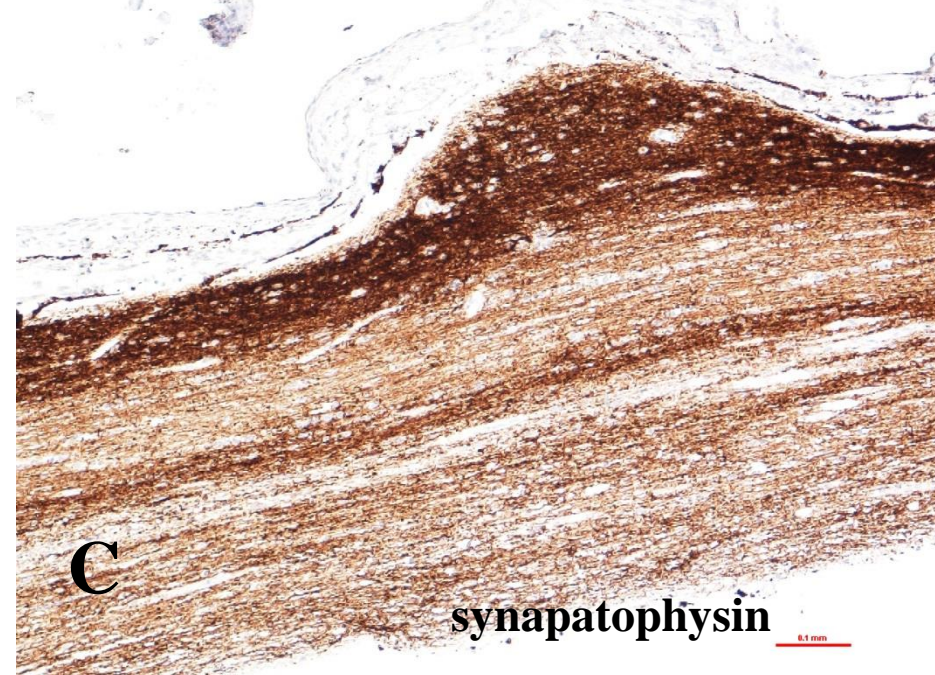
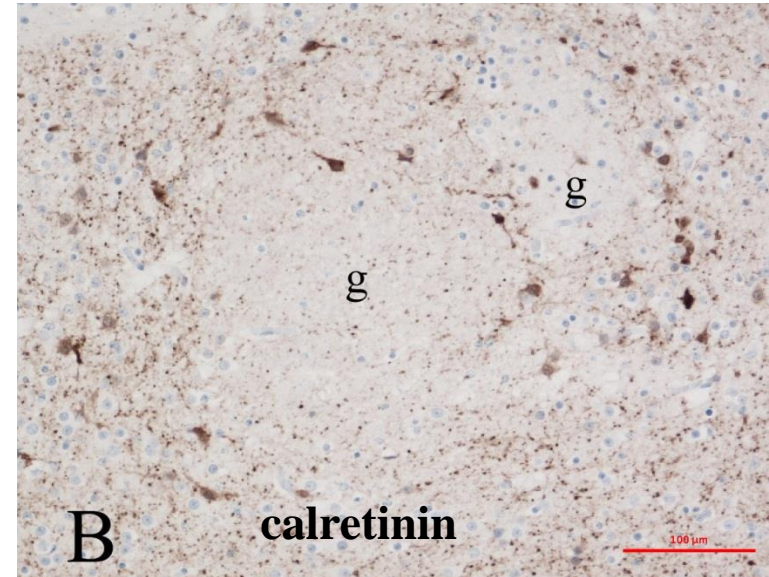
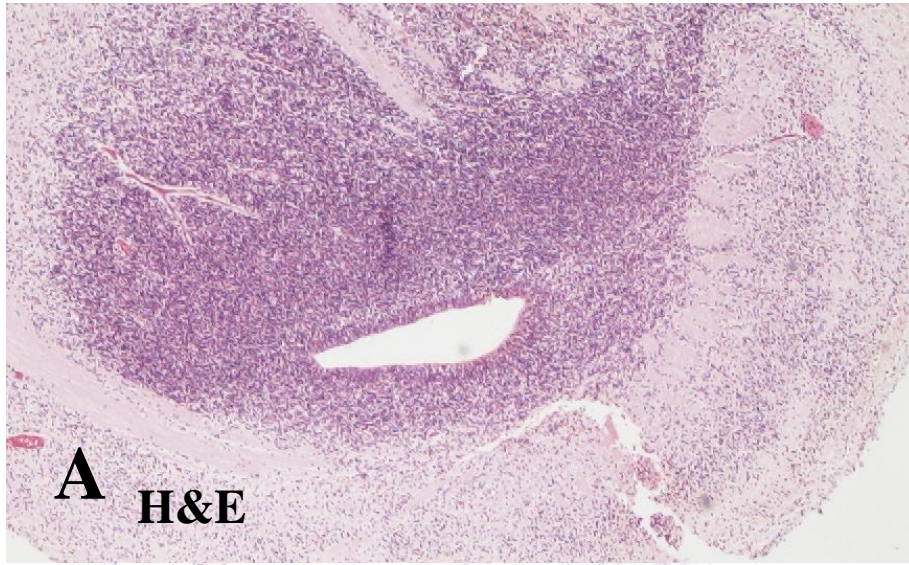
**Full-term neonate:** some synaptic glomeruli (g) are still immature and not as intense as others for **calretinin**. Periglomerular inhibitory interneurons (p) and primary olfactory nerve axons (ax) are uniformly strongly reactive.



# Olfactory Thalamic Equivalent

- The olfactory is the only sensory system of the CNS that does not project to the thalamus.
- The olfactory bulb and tract incorporate their own thalamic equivalent, consisting of:
  - A)** multiple concentric layers of axonless GABAergic granular neurons alternating with dendro-dendritic synaptic layers, in the core of olfactory bulb, extending into olfactory tract; no efferent projections beyond
  - B)** periglomerular GABAergic interneurons, most of which are axonless and form dendro-dendritic synapses
  - C)** anterior olfactory nucleus: multiple clusters of glutamatergic and serotonergic neurons within the olfactory tract and between tract and entorhinal cortex of parahippocampal

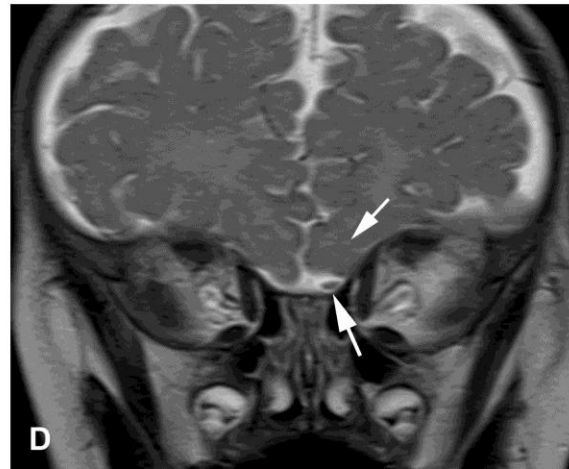
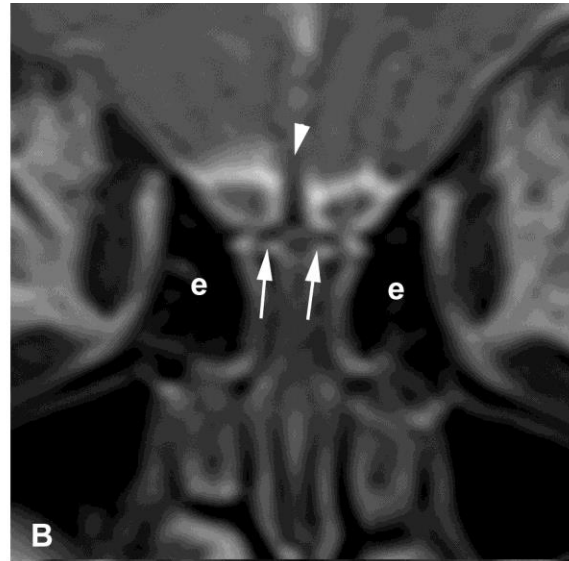
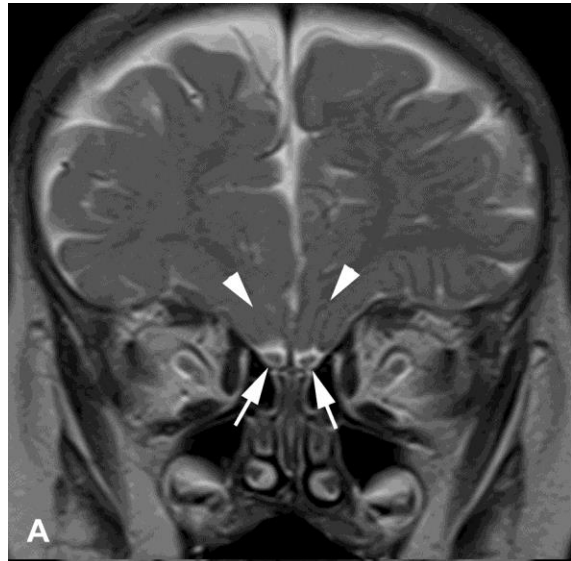




- A)** Granular and progenitor cells form core of the olfactory bulb. Ventricular recess is within this core. 22wk fetus.
- B)** Calretinin immunoreactivity in periglomerular neurons surrounding synaptic glomeruli (g) which are still non-reactive. 19wk normal fetus.
- C)** A nodule of anterior olfactory nucleus within olfactory tract exhibits many synaptic vesicles. 5-mo postnatal.



# MRI-T1, Coronal plane, demonstrates presence or absence of olfactory bulbs and olfactory sulcus for olfactory tract on gyrus rectus



**A, B)** normal bulbs (arrows) and olfactory sulcus (arrowheads);  
**C)** bilateral absence of olfactory bulbs with well formed interhemispheric fissure (not holoprosencephaly);  
**D)** 10-year-old girl with absent R olfactory bulb; L bulb present but small; no other brain lesions by MRI; focal epilepsy.

*(Courtesy of Dr. Xing-Chang Wei, Dept. of Radiology/Diagnostic Imaging, Alberta Children's Hosp. Calgary, Canada)*