

BASICS OF NEUROBIOLOGY

OLFACTORY SYSTEM

ZSOLT LIPOSITS

Basics of Neurobiology: Olfactory system

FEATURES OF THE OLFACTORY SYSTEM

ODORANTS ARE CHEMICAL SUBSTANCES OF THE ENVIRONMENT THAT ARE SENSED BY THE OLFACTORY SYSTEM. THEY PROVIDE INFORMATION ABOUT MEMBERS OF THE BIOLOGICAL COMMUNITY AND POTENTIAL HAZARDS THREATENING THE INDIVIDUALS. SPECIES SPECIFIC ODORANTS, CALLED PHEROMONES, ARE LINKED WITH REPRODUCTION

THE HUMAN BEING IS MICROSMATIC AND DEPENDS LESS ON THIS PARTICULAR CHEMICAL SENSE IN COMPARISON WITH DIFFERENT ANIMAL SPECIES

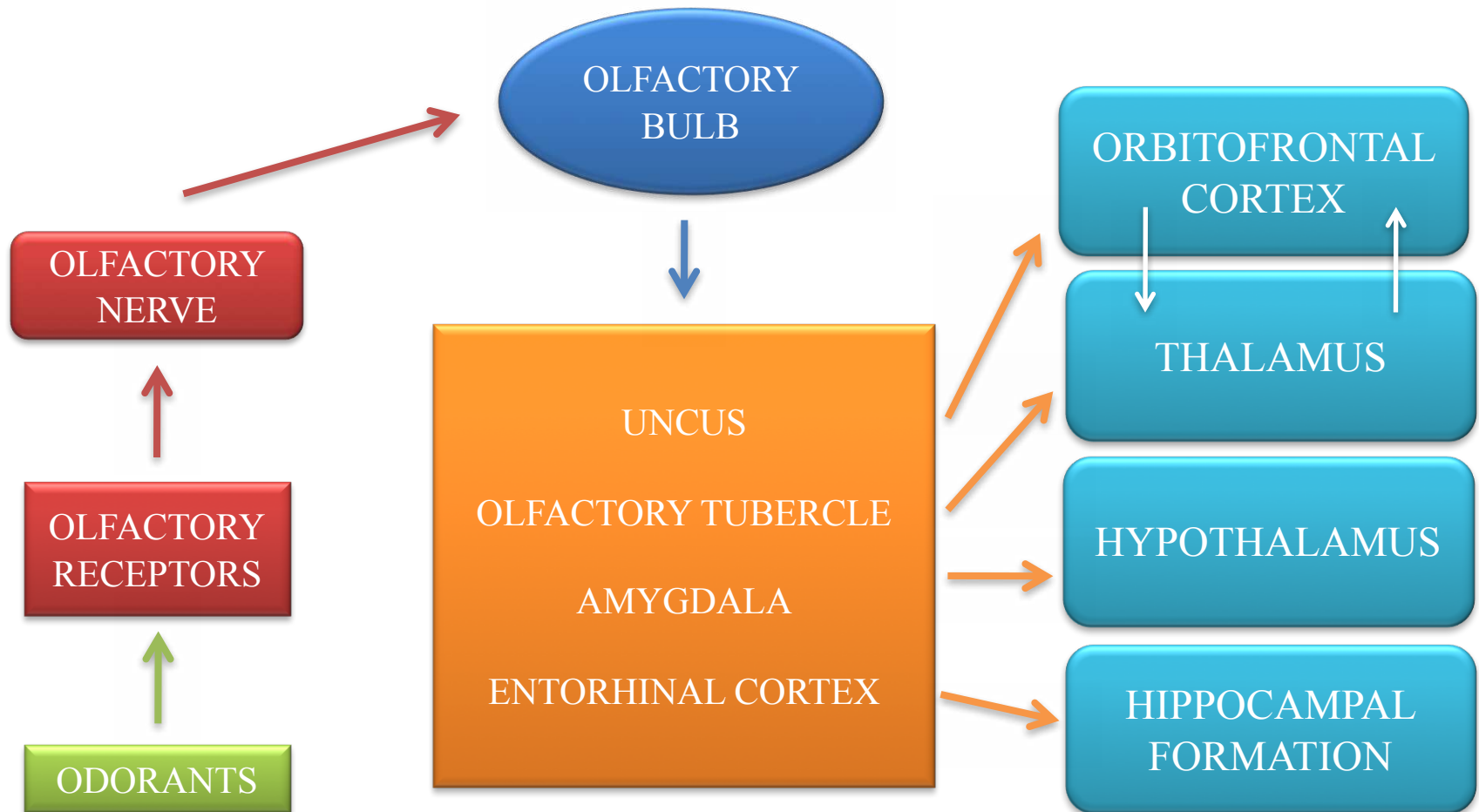
ODORANTS TRIGGER SPECIFIC G PROTEIN-COUPLED RECEPTORS OF THE OLFACTORY EPITHELIUM CELLS. THE INFORMATION OF SMELL IS CONVEYED BY THE OLFACTORY NERVE TO THE OLFACTORY BULB FOR INITIAL PROCESSING

THE OLFACTORY BULB PROJECTS VIA THE OLFACTORY TRACT TO HIGHER PROCESSING CENTERS LIKE THE PYRIFORM CORTEX AND THE AMYGDALA. THESE AREAS RELAY THE INFORMATION FURTHER TO THE ORBITOFRONTAL CORTEX, HYPOTHALAMUS AND THE HIPPOCAMPUS

THESE CONNECTIONS ALLOW THE CONSCIOUS PERCEPTION OF SMELL AND PROCESSING ITS EMOTION, MOTIVATION AND MEMORY-RELATED COMPONENTS

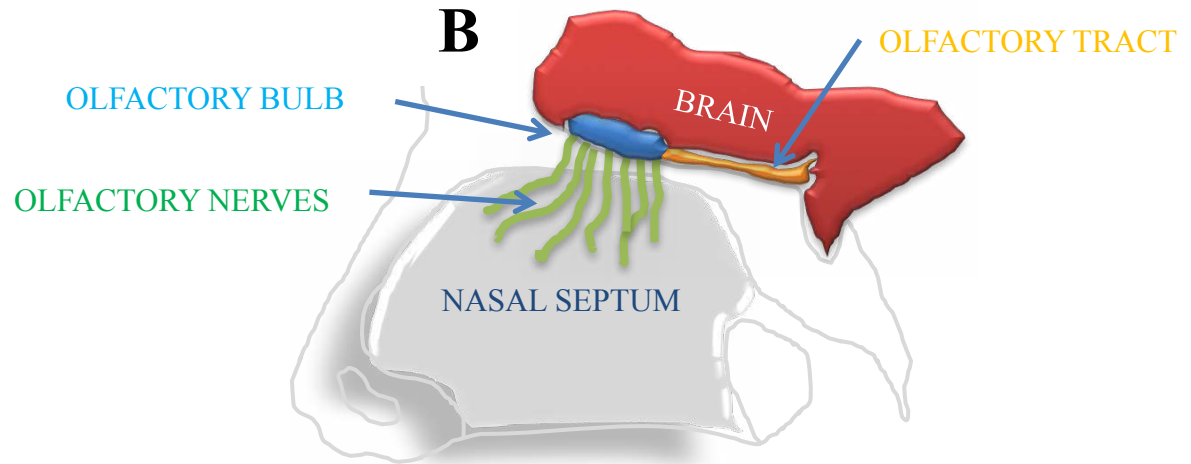
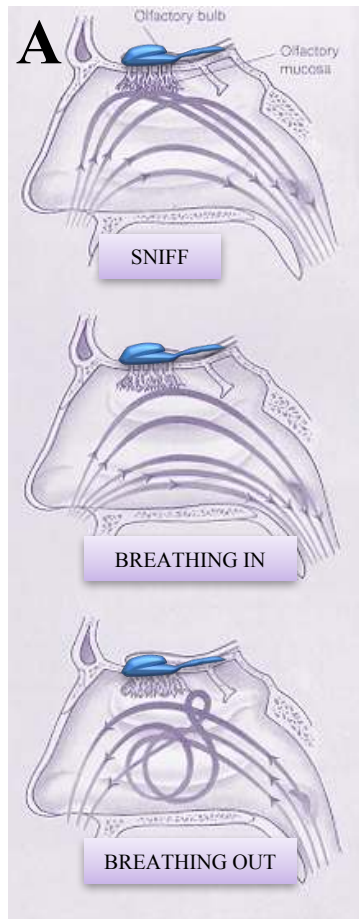
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GENERAL DESIGN OF THE SYSTEM PROCESSING OLFACTORY INFORMATION



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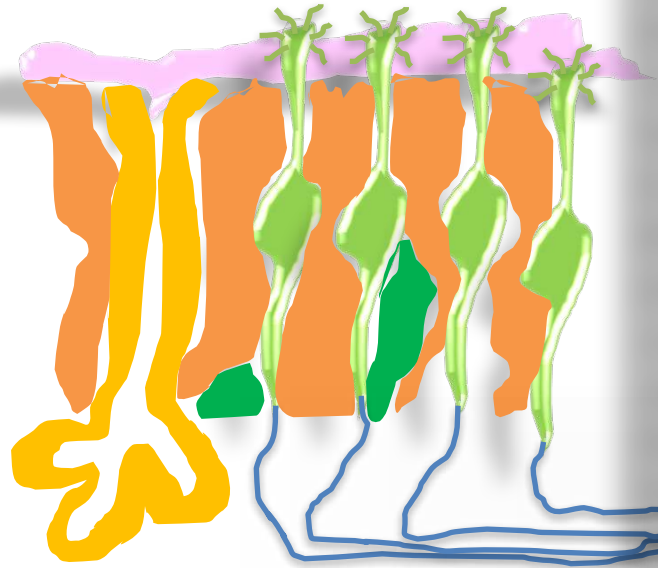
THE OLFACTORY APPARATUS *IN SITU*



PRIMARY SENSORY EPITHEL CELLS ARE EMBEDDED IN THE OLFACTORY MUCOSA SITUATED AT THE TOP OF THE NASAL CAVITY. THE CELLS POSSESS CILIA THAT CONTAIN ODORANT RECEPTORS. WATER SOLUBLE ODORANT SUBSTANCES ARE TAKEN THROUGH THE NASAL CAVITY DURING A SNIFF OR BREATHING (A) WHERE THEY BIND TO THEIR RECEPTORS. FIGURE B DEPICTS THE OLFACTORY SYSTEM *IN SITU*

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THE STRUCTURE OF THE OLFACTORY EPITHELIUM

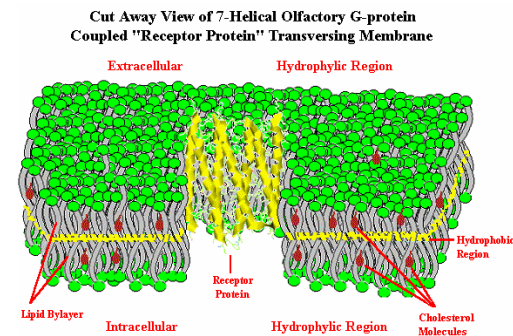
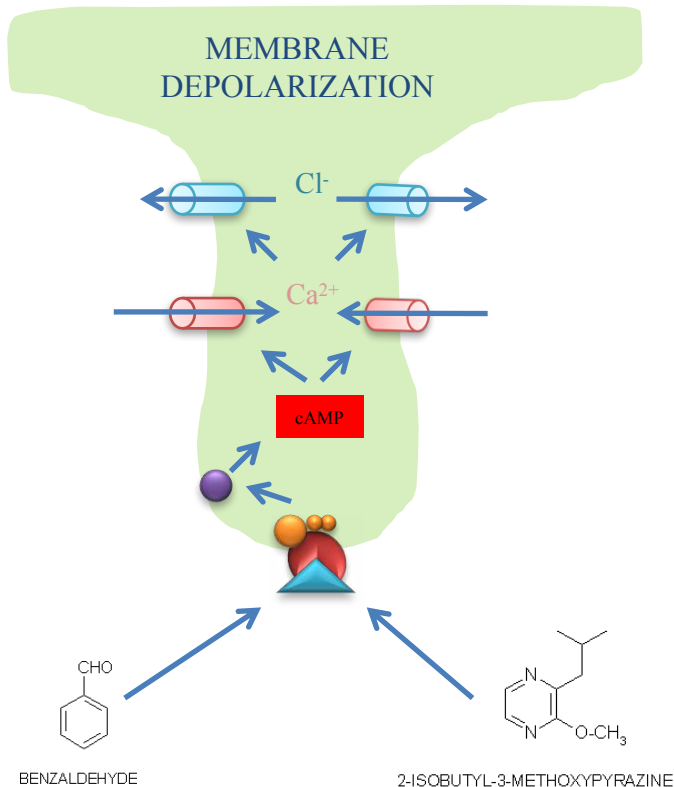


THE **SENSORY EPITHEL CELLS** ARE BIPOLAR. THEIR PERIPHERAL POLES FORM OLFACTORY VESICLES THAT ARE DECORATED WITH CILIA. THE VESICLES WITH THE CILIA ARE EMBEDDED IN A **MUCOUS FLUID** PRODUCED BY SPECIAL **GLANDS**. THE SENSORY CELLS ARE SURROUNDED BY **SUPPORTING EPITHEL CELLS**. THE OLFACTORY EPITHELIUM HAS A REMARKABLE REGENERATIVE CAPACITY. THERE ARE ABOUT 25 MILLION CELLS ON EACH SIDE AND SURVIVE FOR TWO MONTHS. THE RENEWAL ORIGINATES FROM THE **BASAL CELLS** THAT SHOW HIGH MITOTIC ACTIVITY. THE **AXON PROCESSES** OF THE BIPOLAR CELLS GATHER INTO 20 BUNDLES ON EACH SIDE AND ENTER THE ANTERIOR CEREBRAL FOSSA OF THE SKULL THROUGH THE CRIBRIFORM PLATE. THEY TERMINATE IN THE OLFACTORY BULB. NOTE, THAT THE BULB HAS TO ADAPT TO THE CONTINUOUSLY INGROWING AXONS

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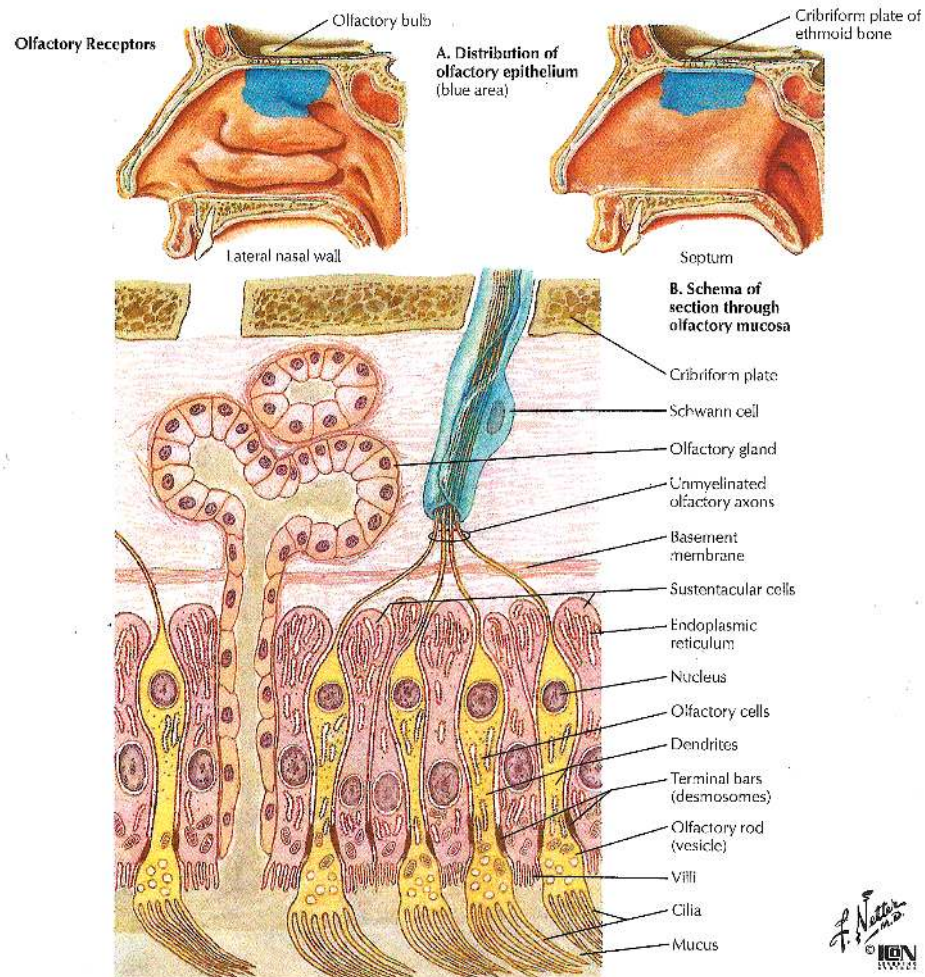
THE OLFACTORY RECEPTOR AND SIGNAL TRANSDUCTION

NOBEL PRIZE WAS AWARDED TO R. AXEL AND L. BUCK IN 2004 FOR THE DISCOVERY OF THE SEVEN TRANSMEMBRANE DOMAIN **ODORANT RECEPTOR PROTEIN**. BINDING OF THE **LIGAND** ACTIVATES **G PROTEINS** THAT IN TURN ACTIVATE **ADENYL CYCLASE III** GENERATING **cAMP**. IT IS FOLLOWED BY THE OPENING OF SODIUM/CALCIUM CHANNELS. THE INFLOW OF CALCIUM OPENS CALCIUM-GATED CHLORIDE CHANNELS LEADING TO DEPOLARIZATION OF THE MEMBRANE OF CILIA

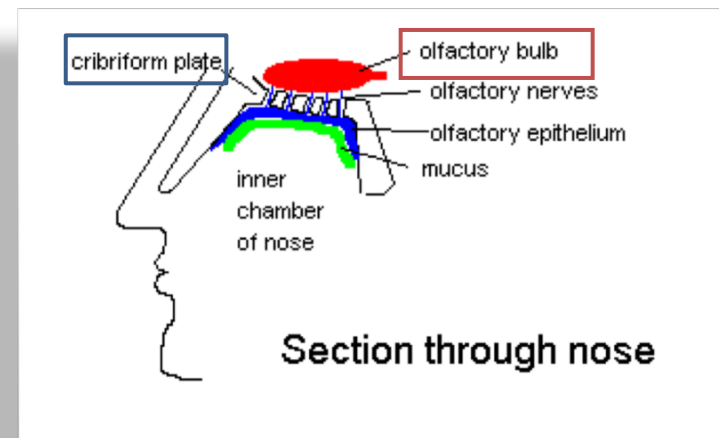
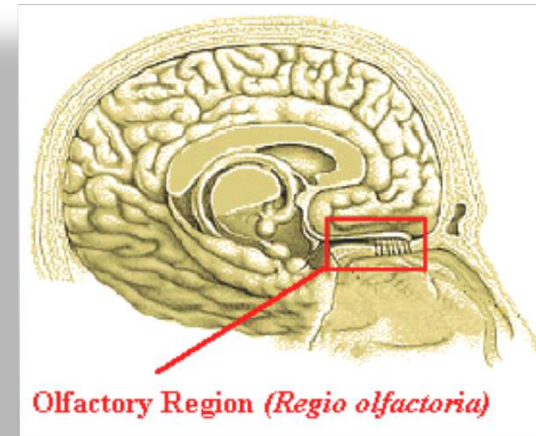
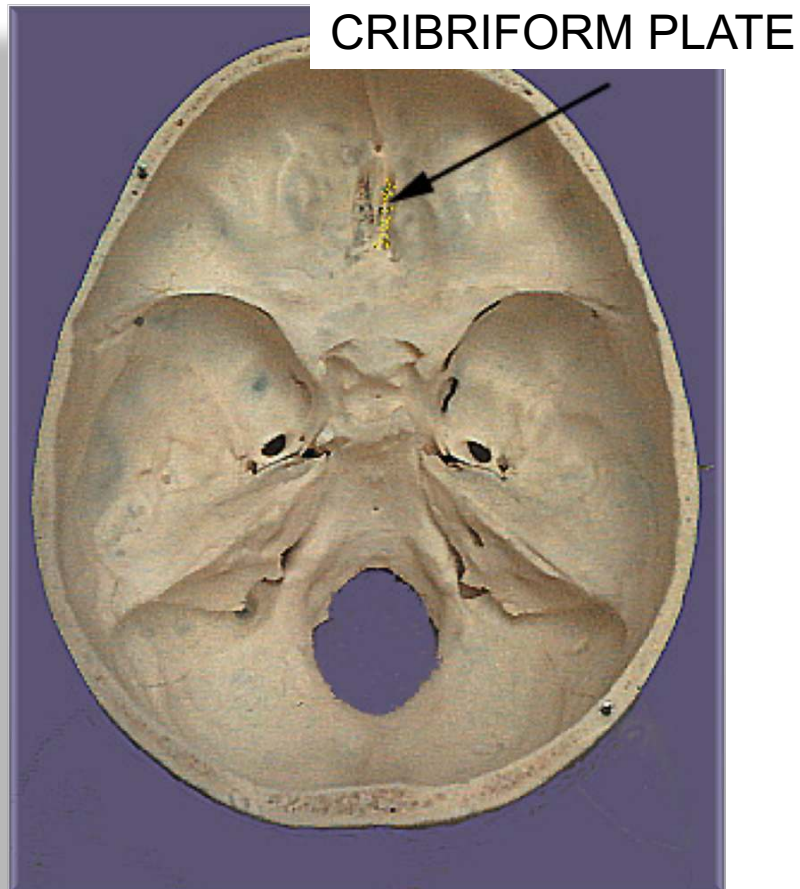


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THE STRUCTURE OF THE OLFACTORY EPITHELIUM

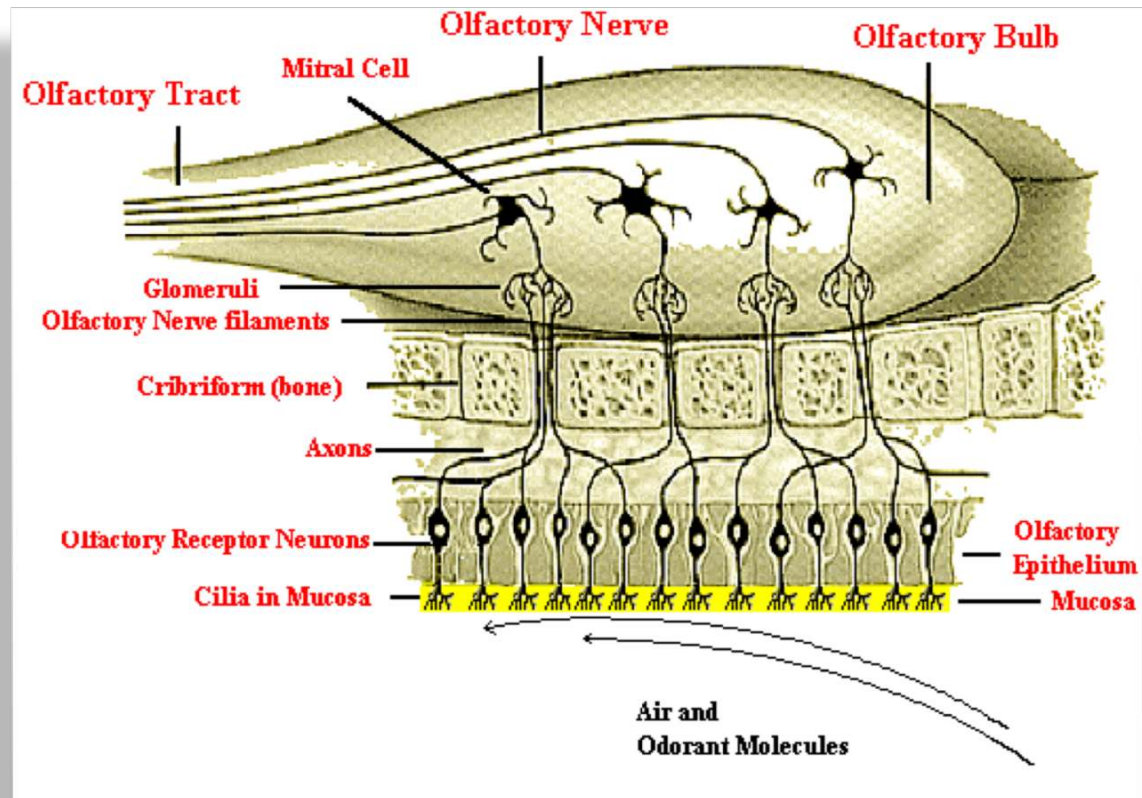


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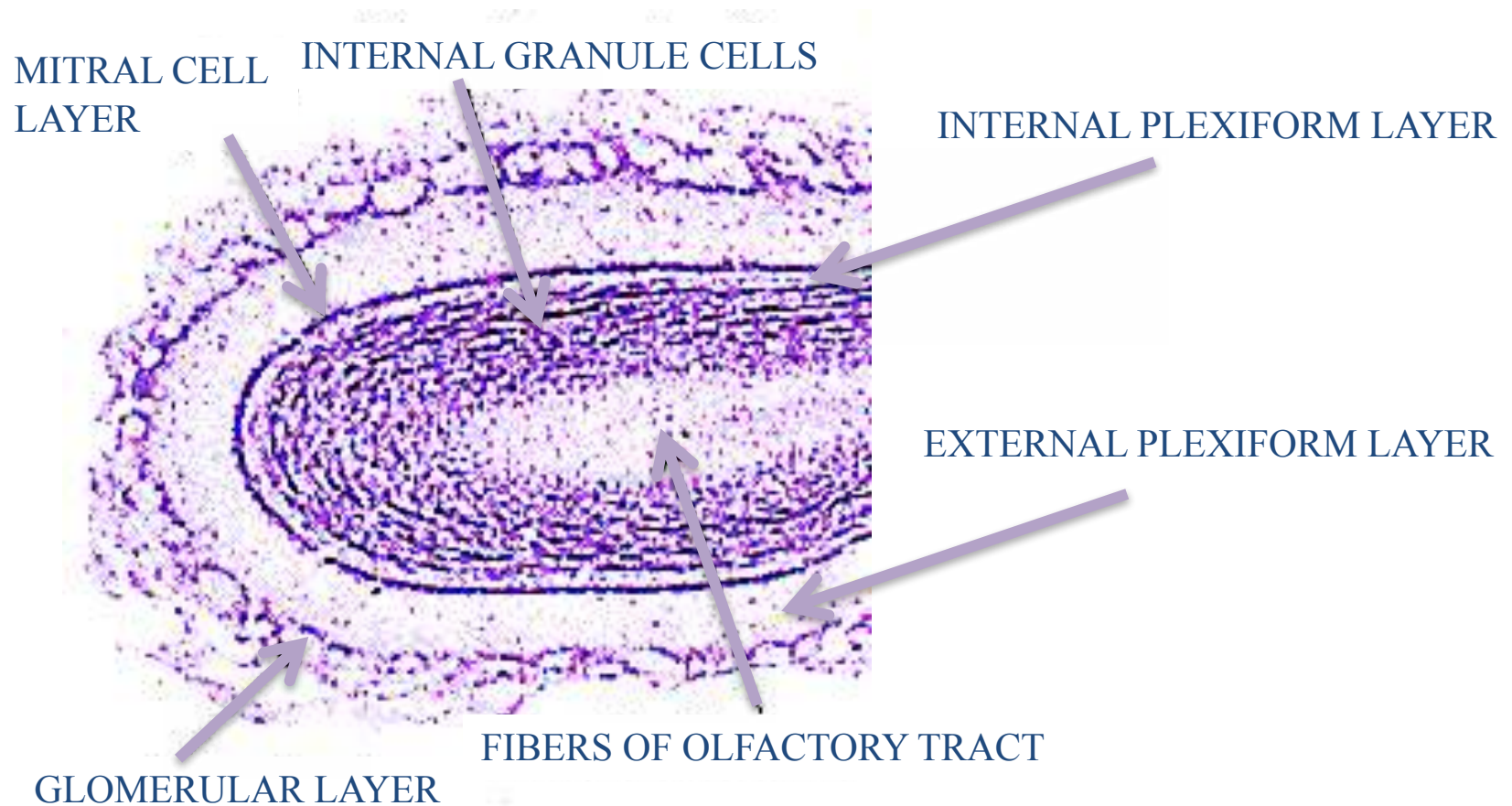
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BULBUS OLFACTORIUS



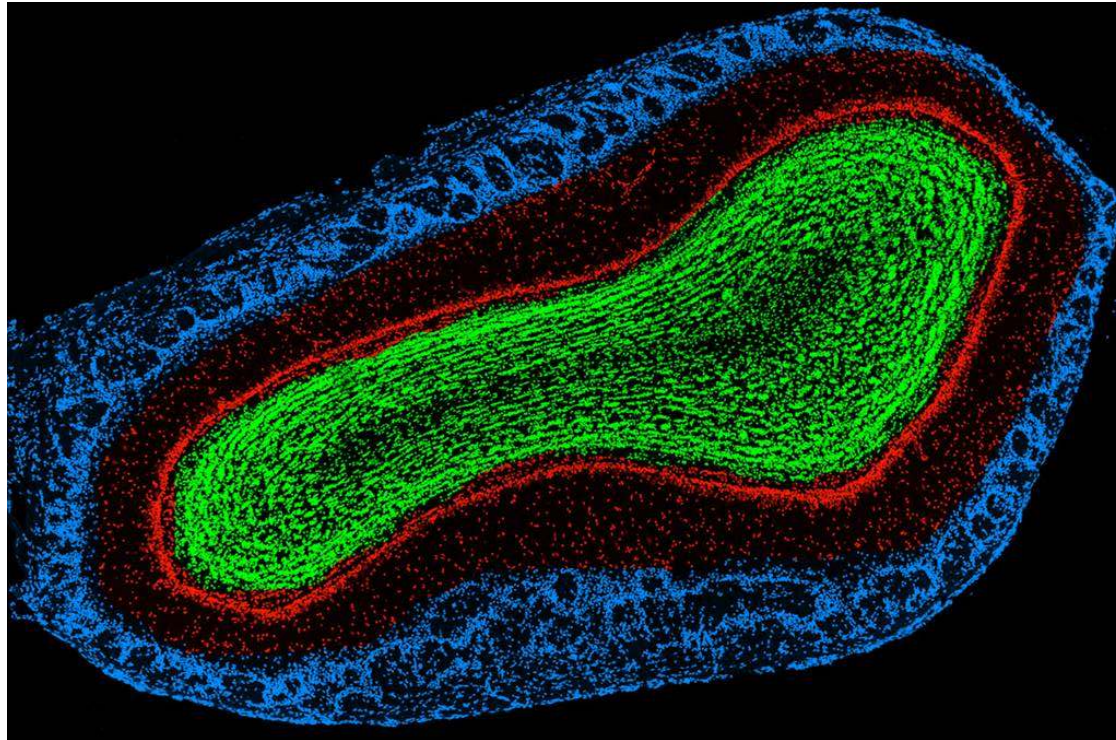
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HISTOLOGY OF THE OLFACTORY BULB



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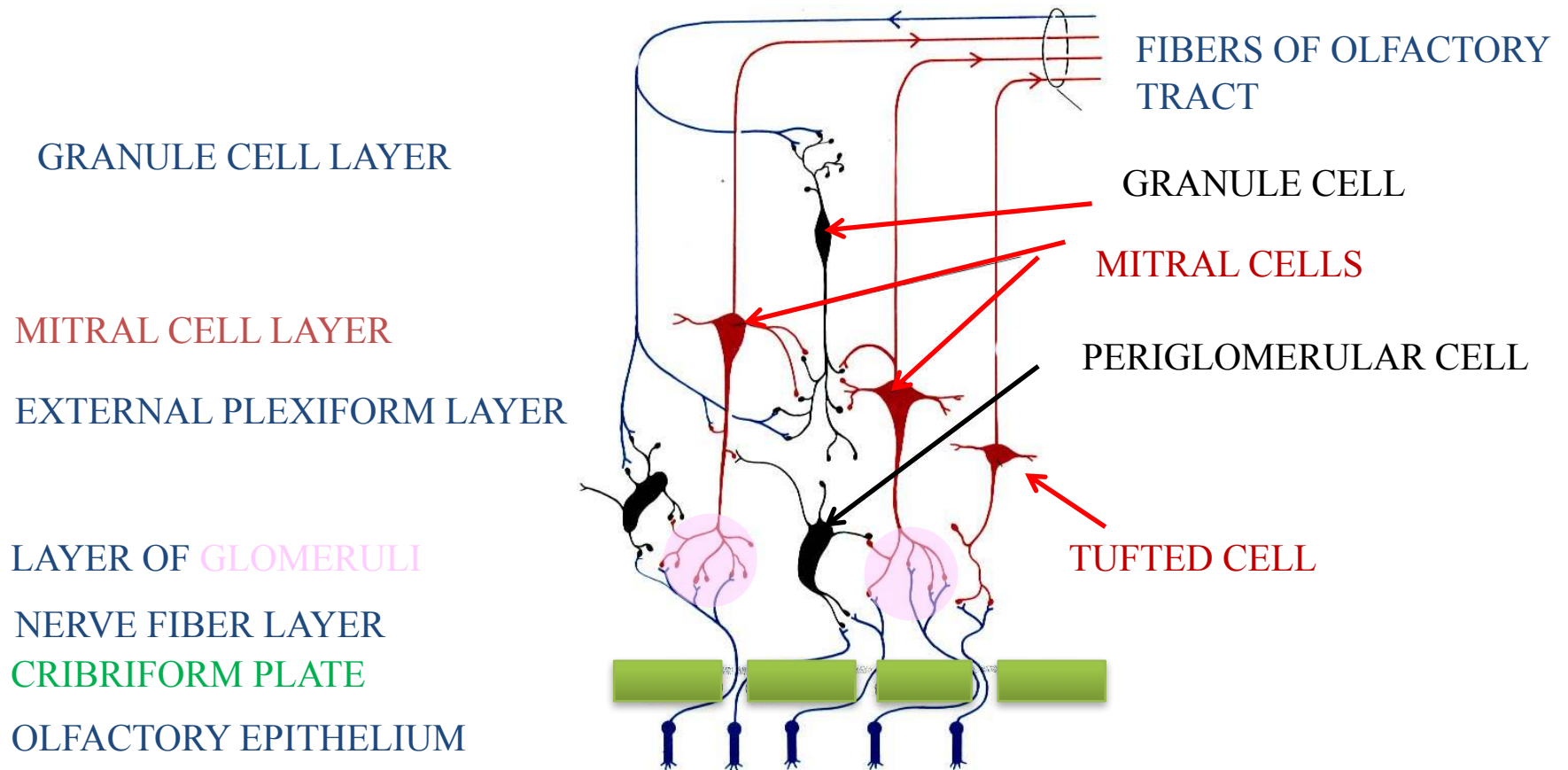
MAIN LAYERS OF THE OLFACTORY BULB



CORONAL IMAGE OF THE MOUSE OLFACTORY BULB. **BLUE** - GLOMERULAR LAYER; **RED** - EXTERNAL PLEXIFORM AND MITRAL CELL LAYERS; **GREEN** - INTERNAL PLEXIFORM AND GRANULE CELL LAYERS. *COURTESY OF VALLEY M.*

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NEURONAL NETWORKS OF THE OLFACTORY BULB



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CHARACTERISTICS OF OLFACTORY BULB NETWORKS

THE BULB RECEIVES TWO KINDS OF AFFERENT INPUTS. THE OLFACTORY NERVES FROM OLFACTORY EPITHELIUM AND CENTRIFUGAL FIBERS FROM THE OLFACTORY TUBERCLE AND DIAGONAL BAND CONVEY INFORMATION. THESE SIGNALS ARE EXCITATORY

WITHIN THE BULB, OLFACTORY FIBERS ESTABLISH CONNECTIONS WITH DENDRITES OF MITRAL, TUFTED AND PERIGLOMERULAR CELLS. THESE STRUCTURES TOGETHER FORM THE CHARACTERISTIC COMPOSITIONS OF THE OLFACTORY BULB, THE GLOMERULI

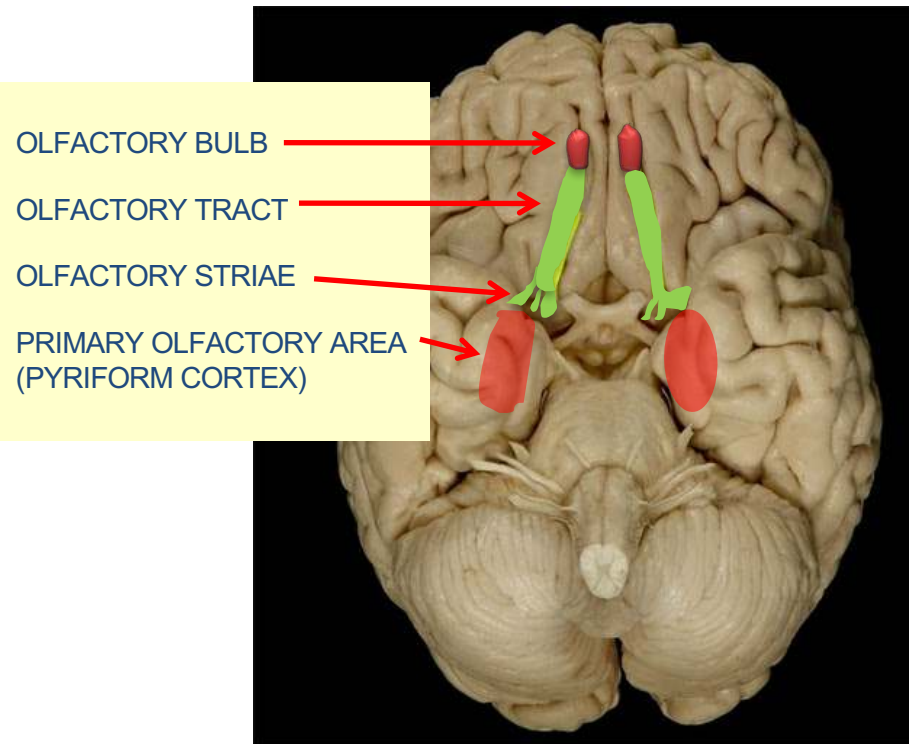
THE CENTRIFUGAL FIBERS COMMUNICATE MAINLY WITH THE INHIBITORY PERIGLOMERULAR AND THE GRANULE CELLS

GRANULE CELLS HAVE NO DEFINITIVE AXONS. THEIR DENDRITES PICK UP THE INFORMATION FROM THE CENTRIFUGAL FIBERS AND ESTABLISH CONNECTIONS WITH MITRAL CELL DENDRITES. THEY CONTRIBUTE TO LATERAL INHIBITION. THE INHIBITORY CELLS ARE REPLACED THROUGHOUT LIFE

THE EFFERENT PROJECTIONS ARE SENT BY AXONS OF MITRAL AND TUFTED CELLS VIA THE OLFACTORY TRACT

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PROJECTIONS OF THE OLFACTORY BULB. PRIMARY OLFACTORY AREA



FROM THE OLFACTORY BULB, THE INFORMATION IS TAKEN VIA THE OLFACTORY TRACT AND OLFACTORY STRIAE TO HIGHER LEVEL PROCESSING CENTERS. THE LATERAL STRIA IS INTERCONNECTED WITH THE **UNCUS**, THE **ENTORHINAL CORTEX** AND THE **LIMEN INSULAE**. THESE STRUCTURES FORM THE PRIMARY OLFACTORY AREA WHICH IS PEAR-SHAPED IN RODENTS (PYRIFORM CORTEX). THE SYSTEM IS LINKED TO THE AMYGDALA AS WELL. THE CONSCIOUS PERCEPTION OF ODOR TAKES PLACE IN THE **ORBITOFRONTAL AND CINGULATE CORTEX**

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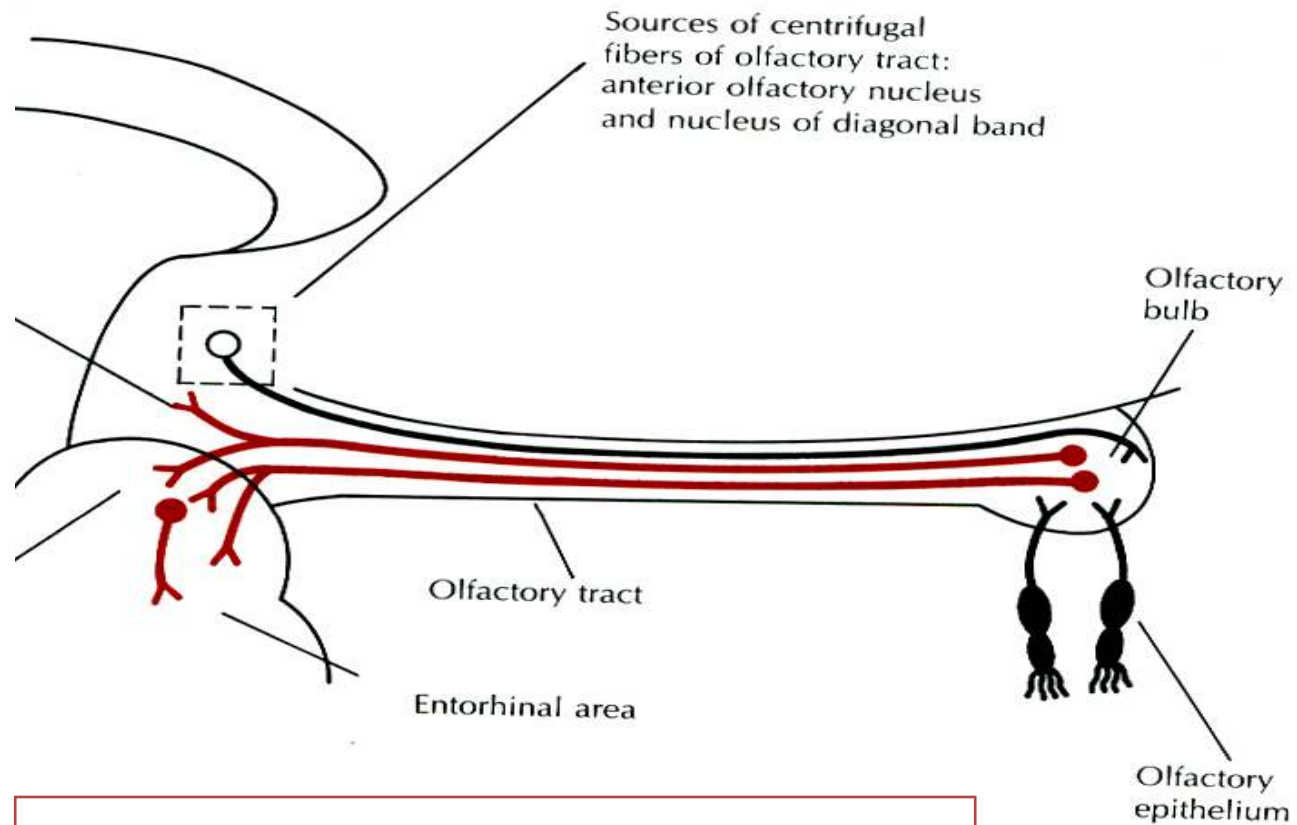
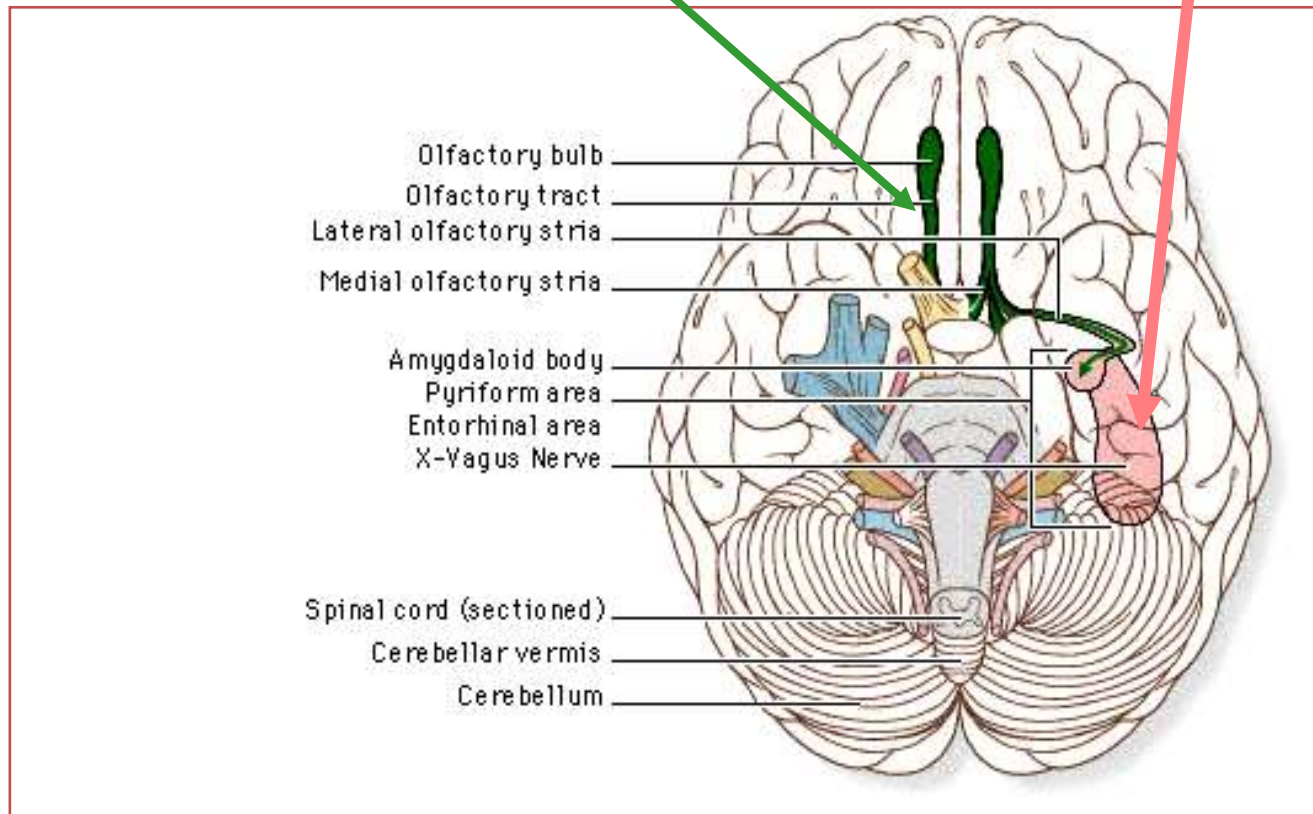


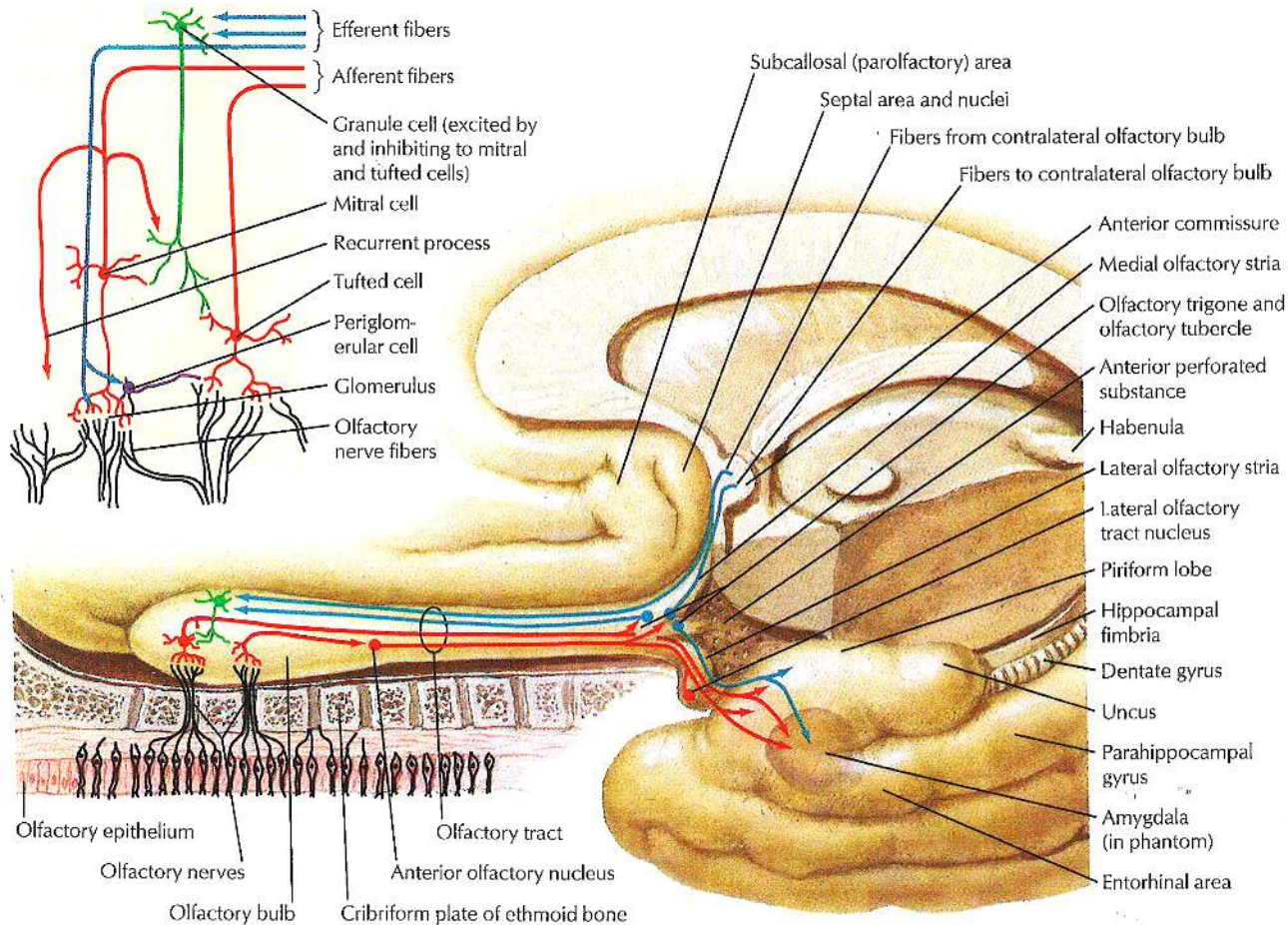
Figure 17-4. Components of the olfactory tract.

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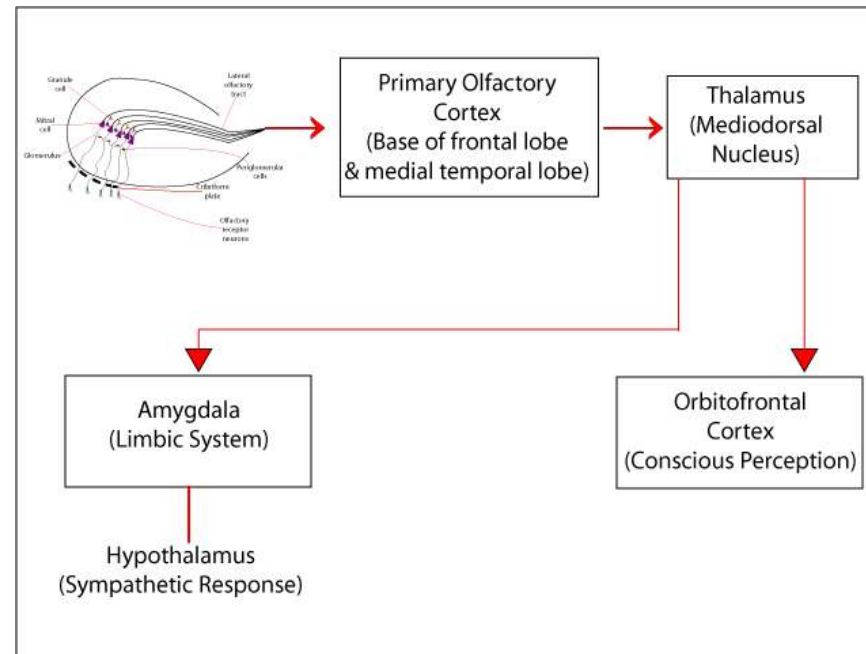
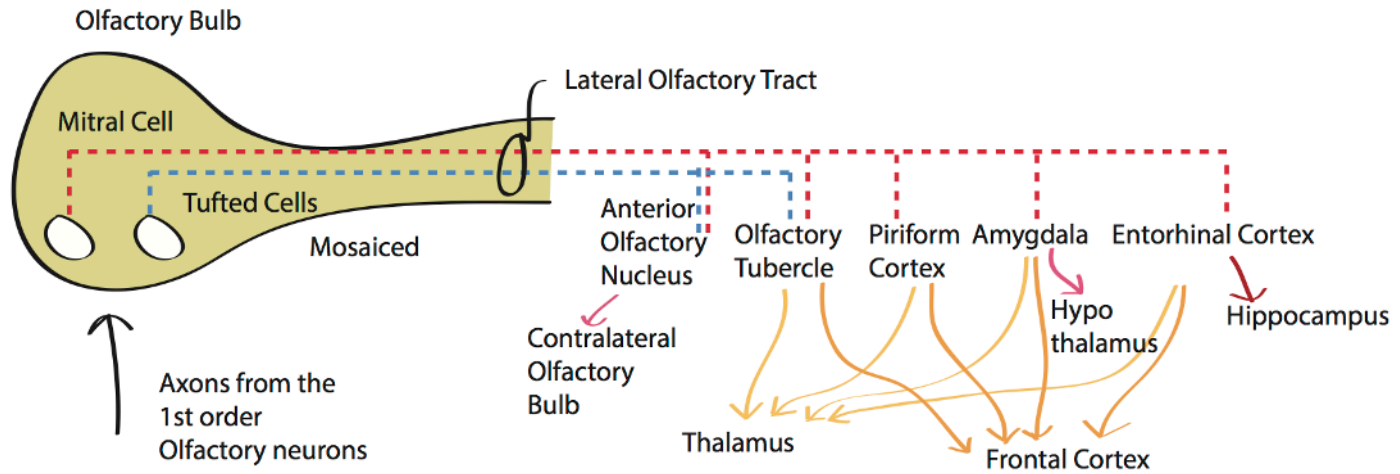
OLFACTORY TRACT AND RHINENCEPHALON



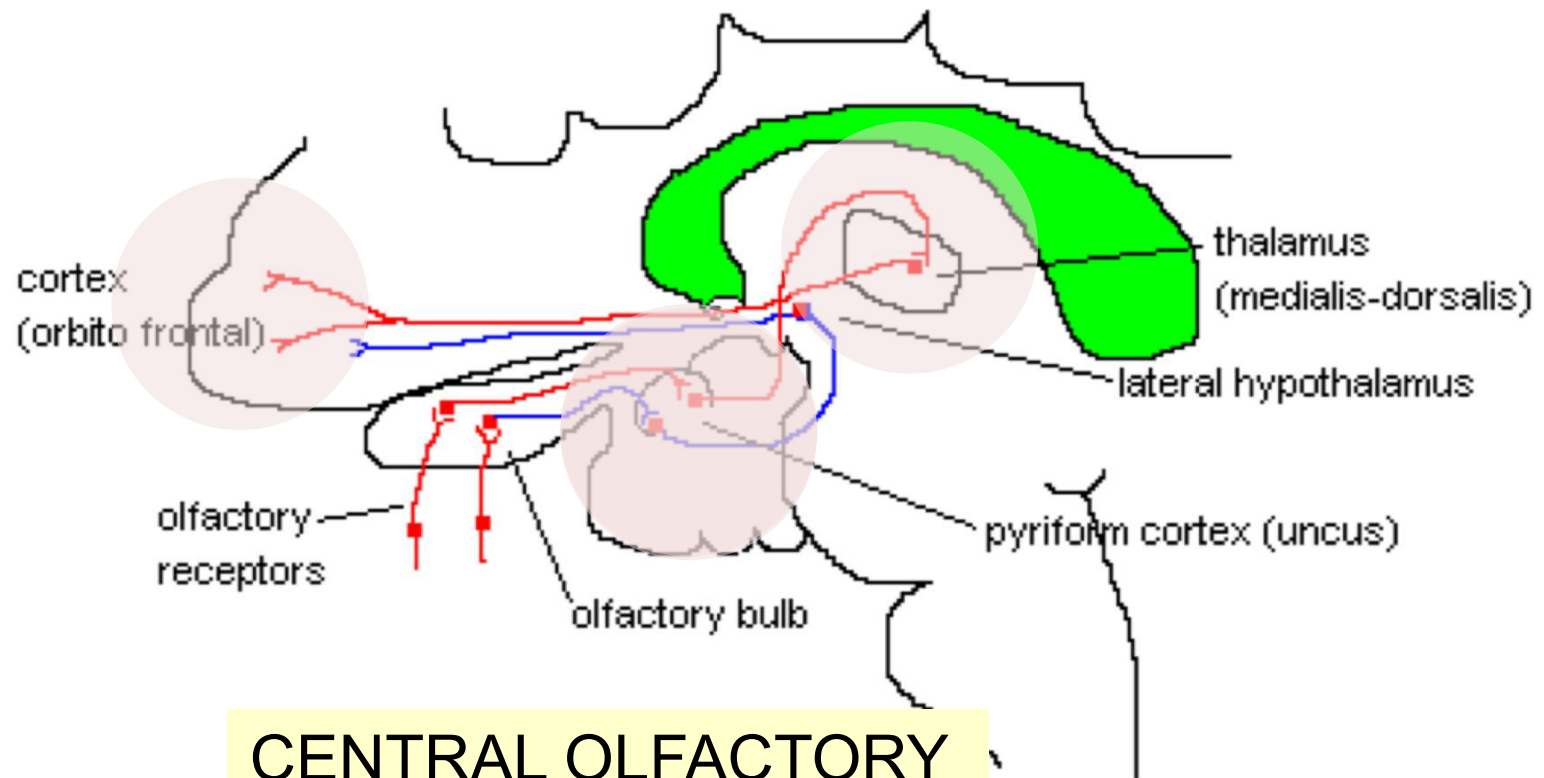
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**CENTRAL OLFATORY
CONNECTION**

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PROCESSING OF OLFACTORY INFORMATION

