Fisiologi Penciuman dan Pengecapan

DR. HANNA CAKRAWATI
LABORATORIUM FISIOLOGI
FK UMM

Goal!

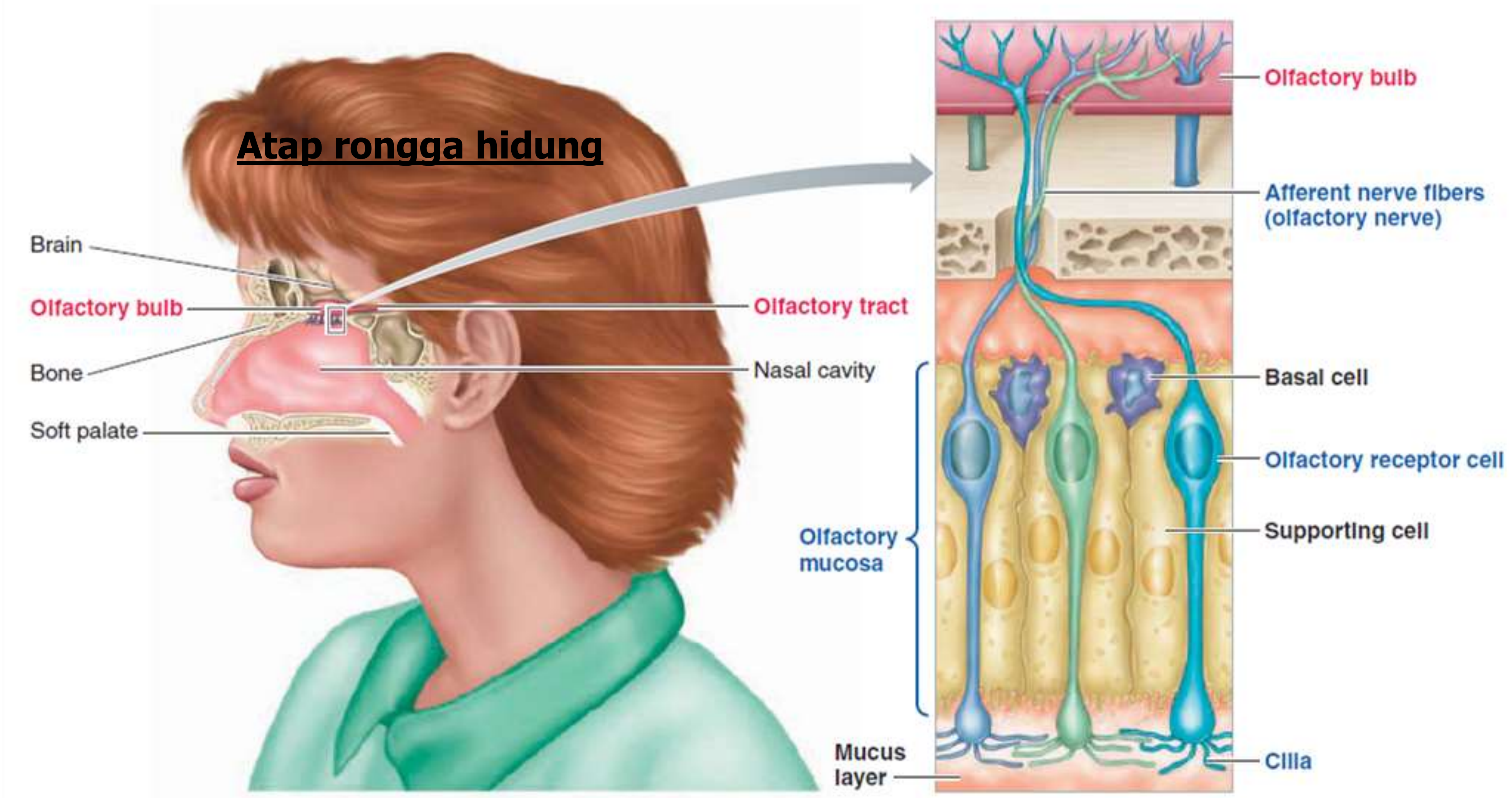
- Menjelaskan fitur dasar unsur-unsur saraf di epitel olfaktorius dan bulbus olfaktorius
- Menjelaskan transduksi sinyal di reseptor odoran
- Meringkas jalur implus yang terbentuk di epitel olfaktorius sehingga mencapai korteks olfaktorius
- Menjelaskan lokasi dan komposisi seluler papil pengecap
- Menyebutkan lima reseptor pengecap utama dan mekanisme transduksi sinyal di berbagai reseptor
- Meringkas jalur impuls yang terbentuk di reseptor pengecap sehingga mencapai korteks insula

Reseptor penciuman maupun pengecapan adalah **kemoreseptor** yang dirangsang oleh molekul yang larut dalam mucus di hidung dan dalam air liur di mulut.

Karena rangsangan datang dari suatu sumber eksternal, keduanya diklasifikasikan sebagai **eksteroreseptor.**

Penciuman

Epitel Olfaktorius dan Bulbus Olfaktorius



● **FIGURE 6-45** Location and structure of the olfactory receptor cells.

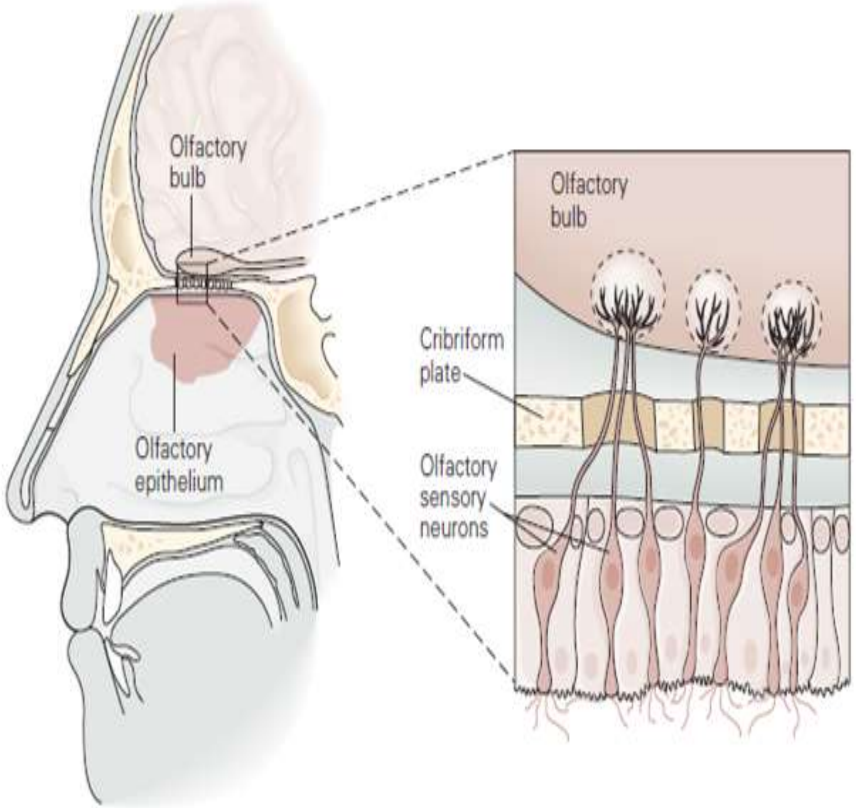
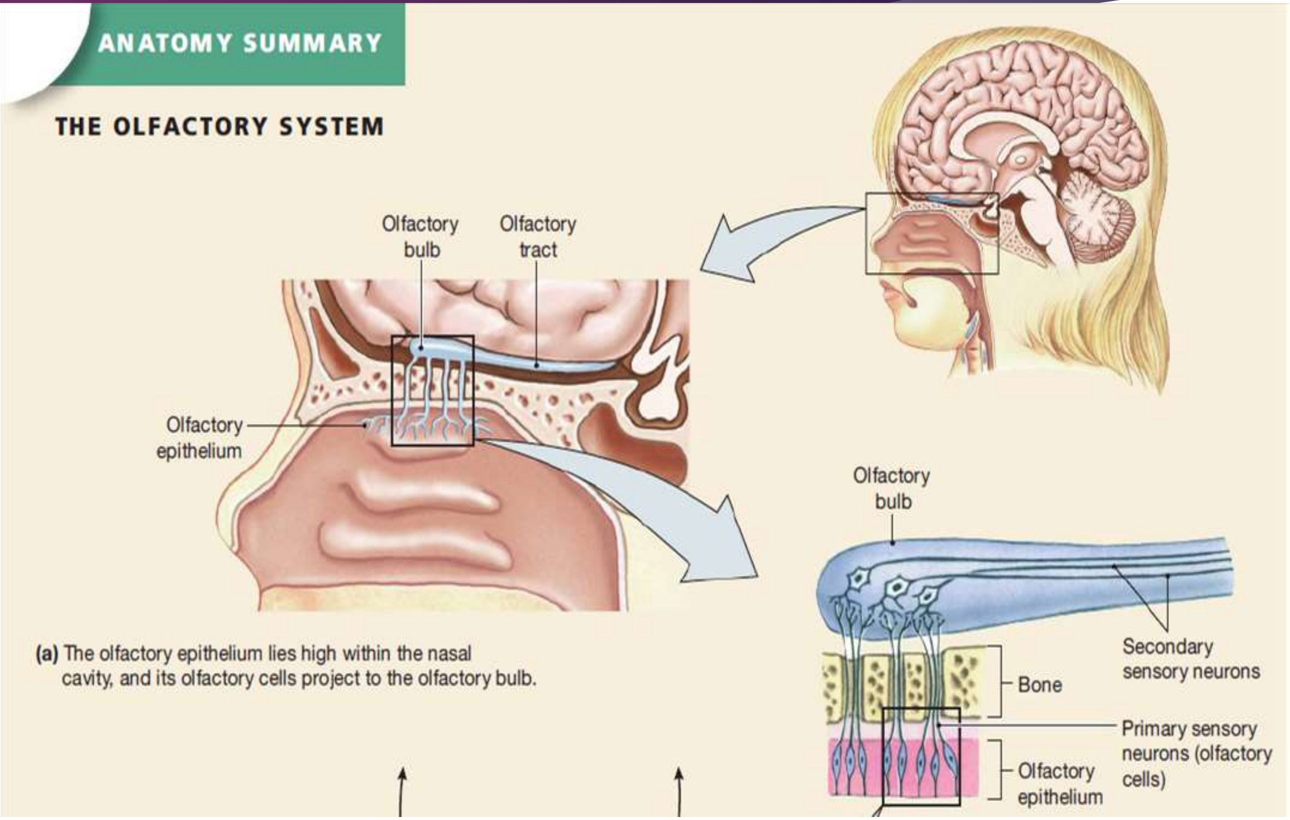


FIGURE 14–1 Olfactory sensory neurons embedded within the olfactory epithelium in the dorsal posterior recess of the nasal cavity. These neurons project axons to the olfactory bulb of the brain, a small ovoid structure that rests on the cribriform plate of the ethmoid bone. (From Kandel ER, Schwartz JH, Jessell TM [editors]: *Principles of Neural Science*, 4th ed. McGraw-Hill, 2000.)



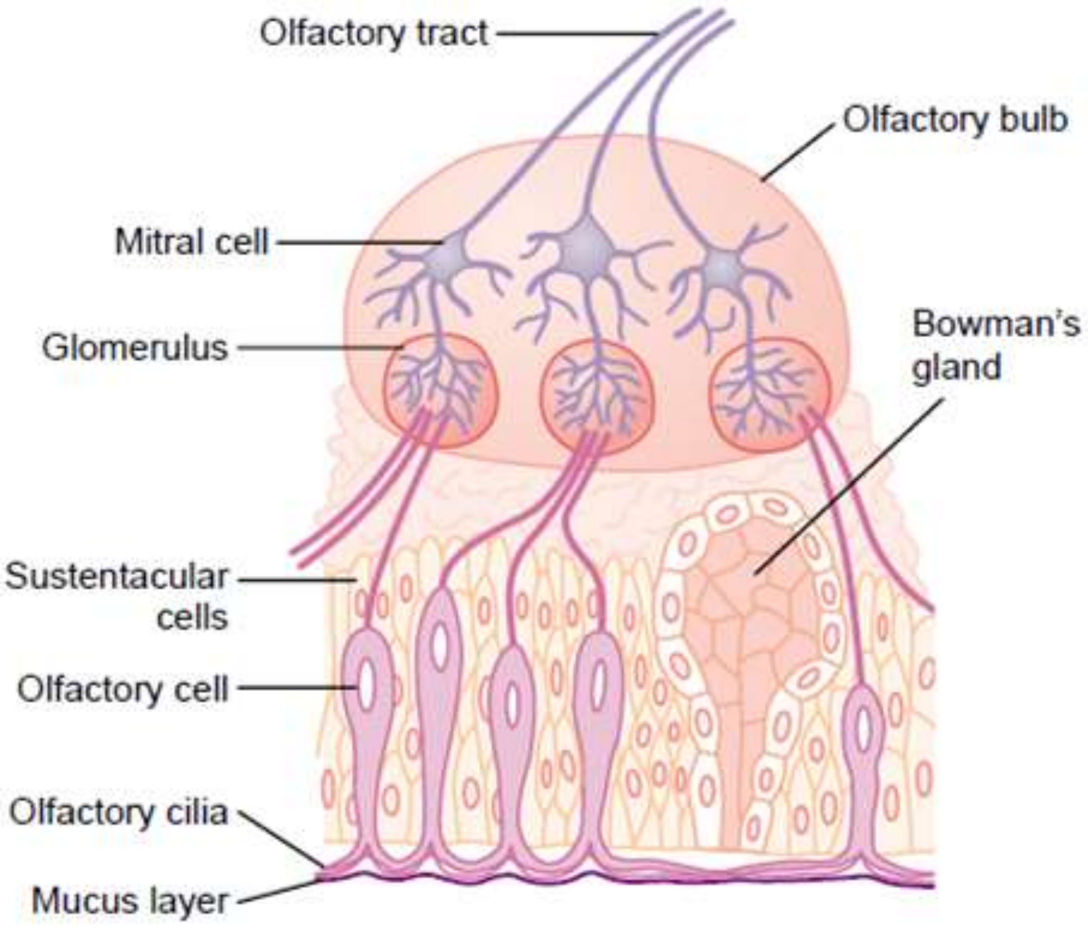


Figure 53–3

Organization of the olfactory membrane and olfactory bulb, and connections to the olfactory tract.

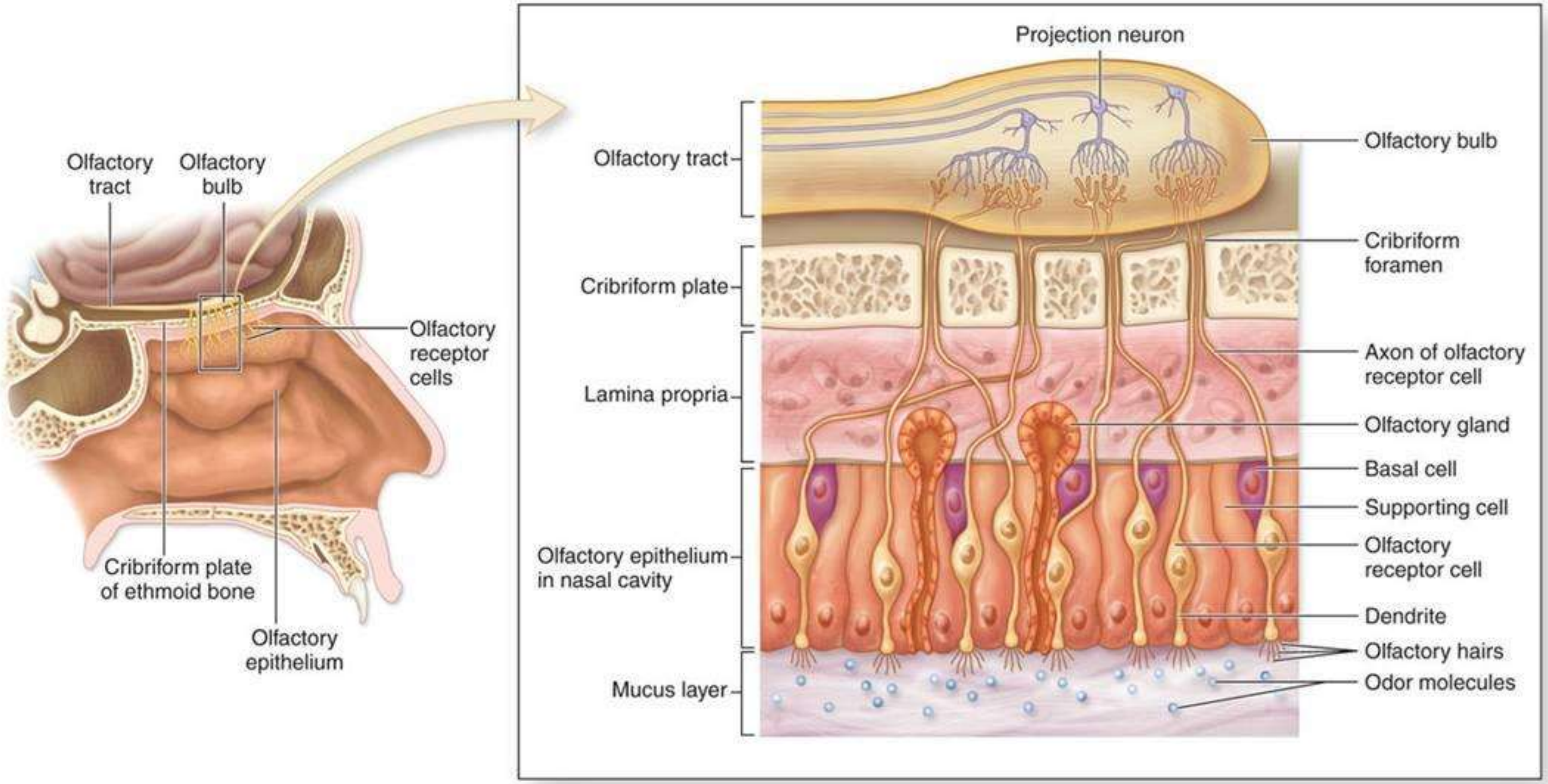
- **Olfactory cell** siklus hidup 4-8 mgg
- **Basal cell** sumber utk membentuk reseptor baru
- **Sustentacular cells dan bowmans gland** sekresi mucus tipis

Dilapisi oleh lapisan mukus

  - Selalu diperbaharui setiap 10 menit
  - Tdd: air, mukopolisakarida, antibodi, enzim, **odorant binding protein**, garam

  Odorant binding protein membantu mengkonsentrasikan odorant dalam mukus

- **Silia** Molekul odoran larut dalam mucus dan mengikat reseptor odoran di silia neuron sensorik



(a) Olfactory receptor cells

Neuron Reseptor Olfactori

- Memiliki dendrit tipis dan tunggal, berakhir dengan knob kecil pada permukaan epitelial, pada sisi sebaliknya berupa axon tipis tak bermyelin.
- Kumpulan axon olfactory membentuk olfactori nerve (NC.I) msk ke plate cribriforme olfactory bulb
- Tonjolan knob dlm mukus layer cilia
- Odoran yang larut dalam mukus berikatan dengan cilia dan mengaktifkan proses transduksi

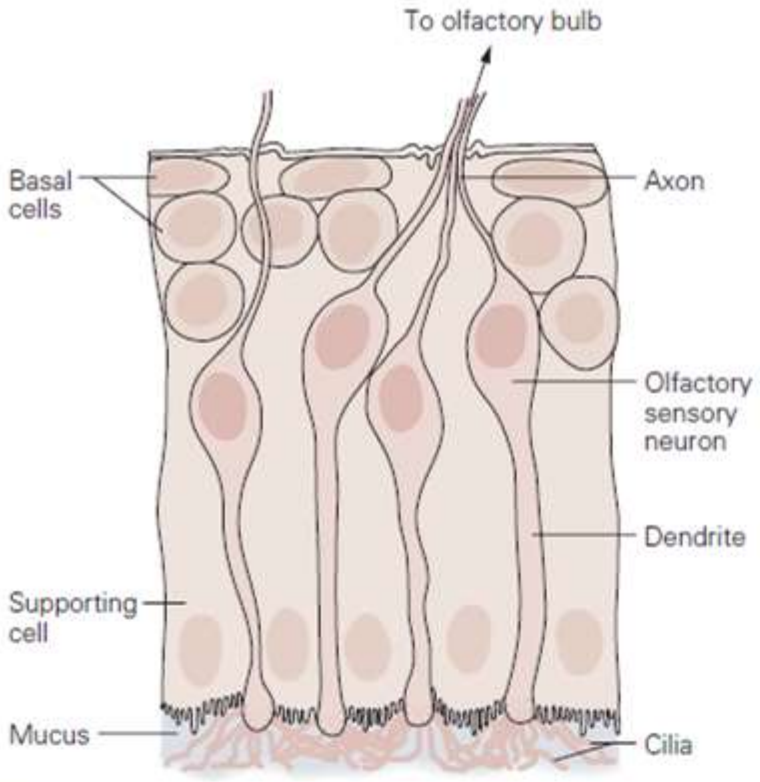
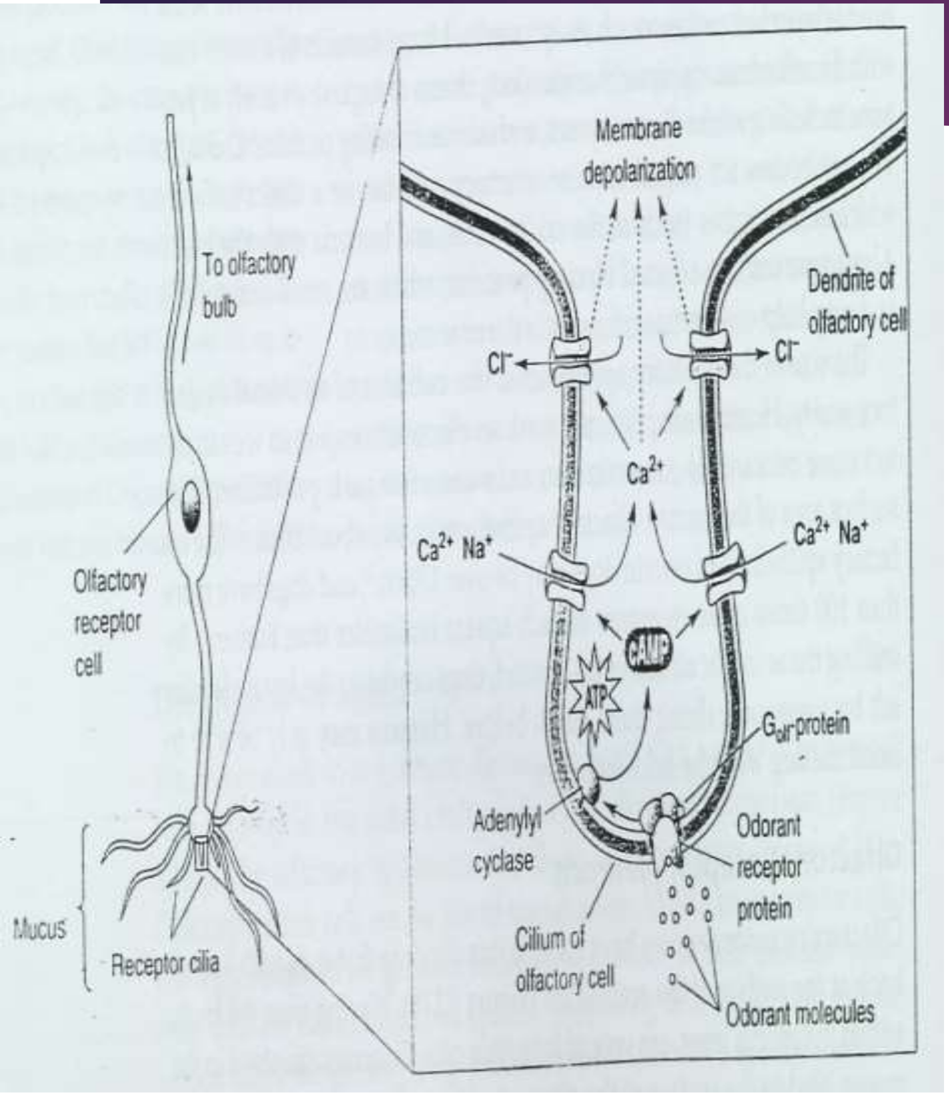


FIGURE 14–2 Structure of the olfactory epithelium. There are three cell types: olfactory sensory neurons, supporting cells, and basal stem cells at the base of the epithelium. Each sensory neuron has a dendrite that projects to the epithelial surface. Numerous cilia protrude into the mucosal layer lining the nasal lumen. A single axon projects from each neuron to the olfactory bulb. Odorants bind to specific odorant receptors on the cilia and initiate a cascade of events leading to generation of action potentials in the sensory axon. (Modified from Kandel ER, Schwartz JH, Jessell TM [editors]: *Principles of Neural Science*, 4th ed. McGraw-Hill, 2000.)

Syarat suatu bahan dapat dibau :

1. Cukup mudah menguap molekul masuk hidung melalui udara inspirasi
2. Cukup larut air dapat masuk lapisan mukus yg menutupi mukosa olfaktorius
3. Mudah larut dalam lemak sel-sel rambut olfaktoria dan ujung luar sel-sel olfaktoria td d zat lemak

Mekanisme Transduksi Silia Olfaktorius terhadap Molekul Odorant



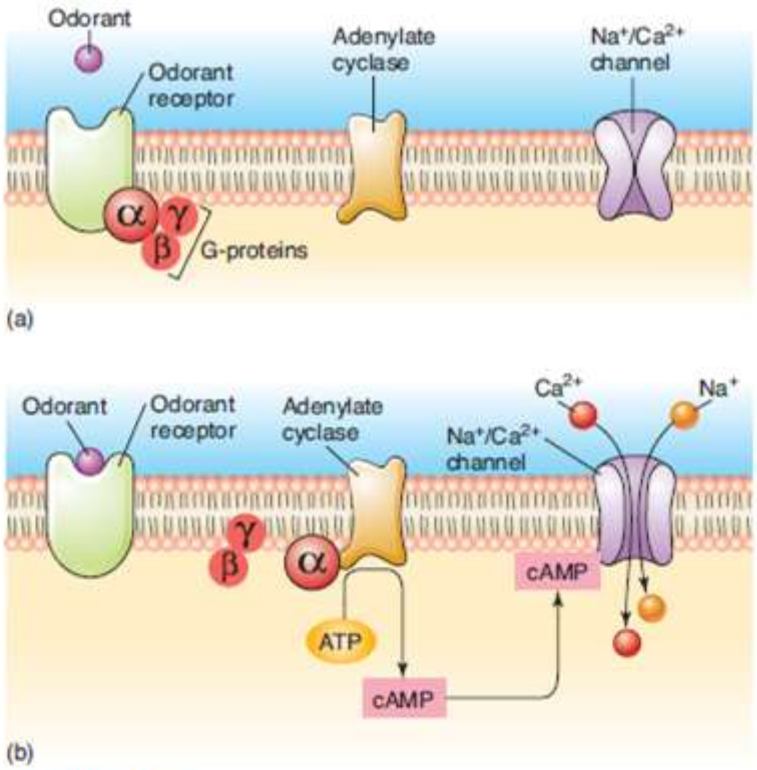


FIGURE 14–5 Signal transduction in an odorant receptor. Olfactory receptors are G protein-coupled receptors that dissociate upon binding to the odorant. The α-subunit of G proteins activates adenylate cyclase to catalyze production of cAMP. cAMP acts as a second messenger to open cation channels. Inward diffusion of Na^+ and Ca^{2+} produces depolarization. (From Fox SI: *Human Physiology.* McGraw-Hill, 2008.)

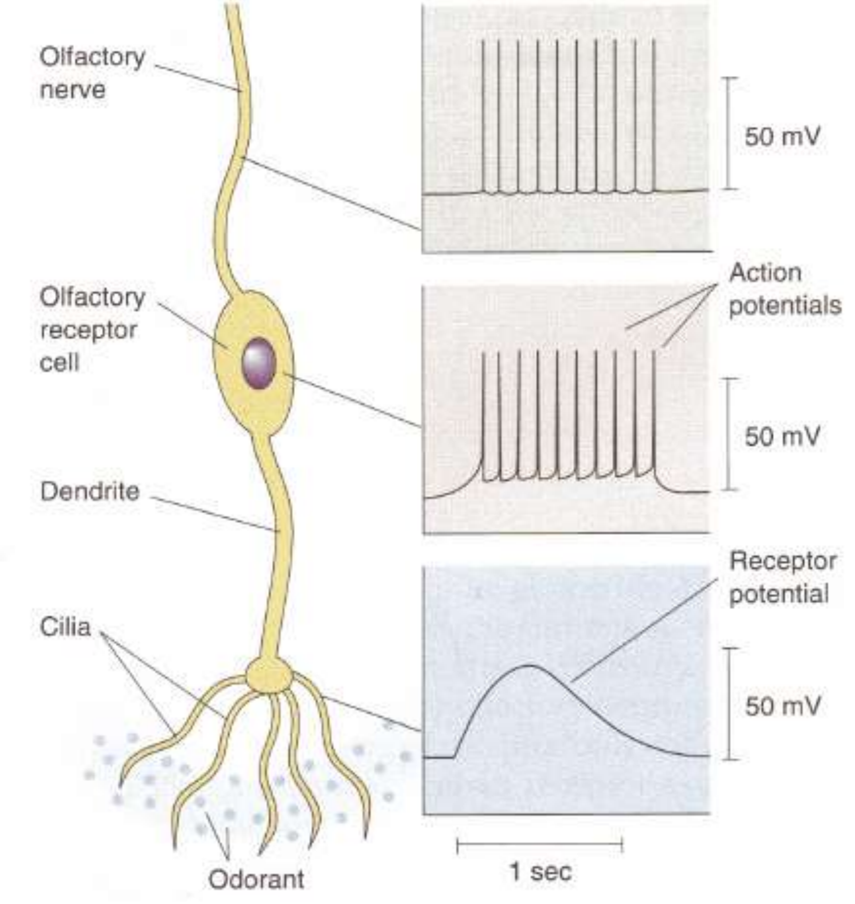
- **Odorant**□ Berikatan dengan protein membran receptor odorant □ stimulasi G-protein □ aktivasi adenyl cyclase □ Pembentukan cAMP □ Ikatan cAMP pada spesifik kation channel □ Pembukaan cation channel dan influx Na dan Ca □ depolarisasi membran (potensial reseptor)
- Ca mengaktivasi chloride channel □ aliran Cl keluar□ memperkuat potensial reseptor melewati ambang□ potensial aksi N C.I

Rekaman Potensial olfactori reseptor sel selama stimulasi

Odorant berikatan dengan membran olfaktori transduksi olfaktori

  potensial reseptor di cilia   dipropagasi di dendrit

  potensial aksi di soma   terus dipropagasi sampai n.olfaktorius (N. I)



Respon olfactori berakhir karena:

- Odorant berdifusi keluar
- Enzim dalam lapisan mukus menguraikan odorant
- cAMP pada sel reseptor mengaktivasi jalur signaling lainnya yang mengakhiri proses transduksi

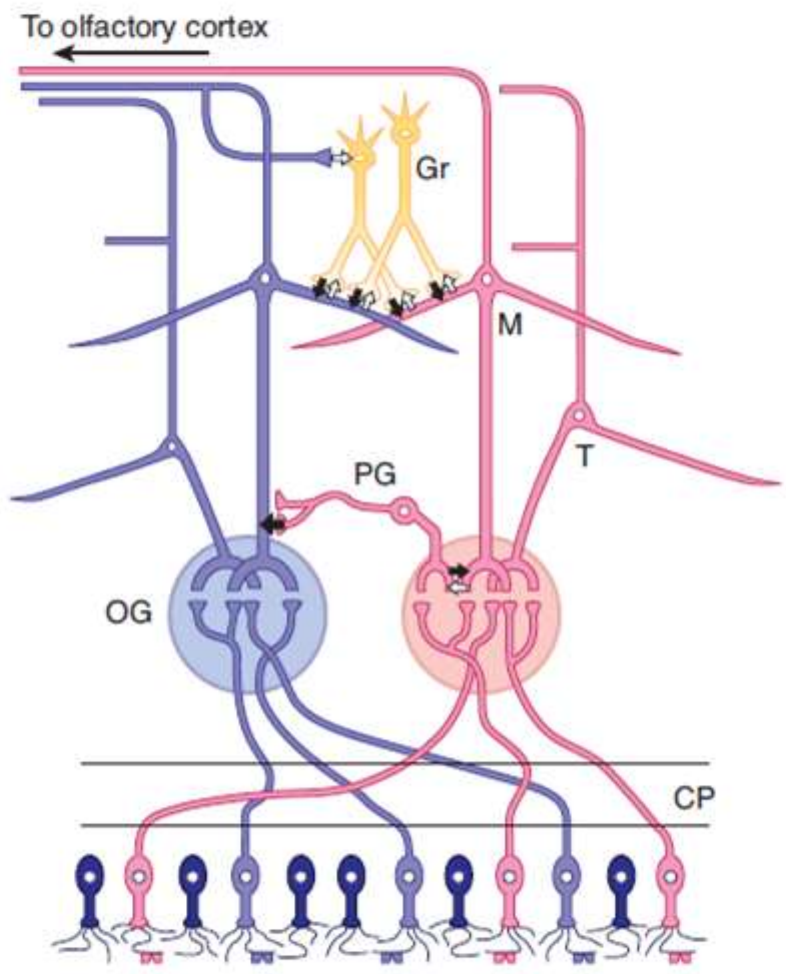
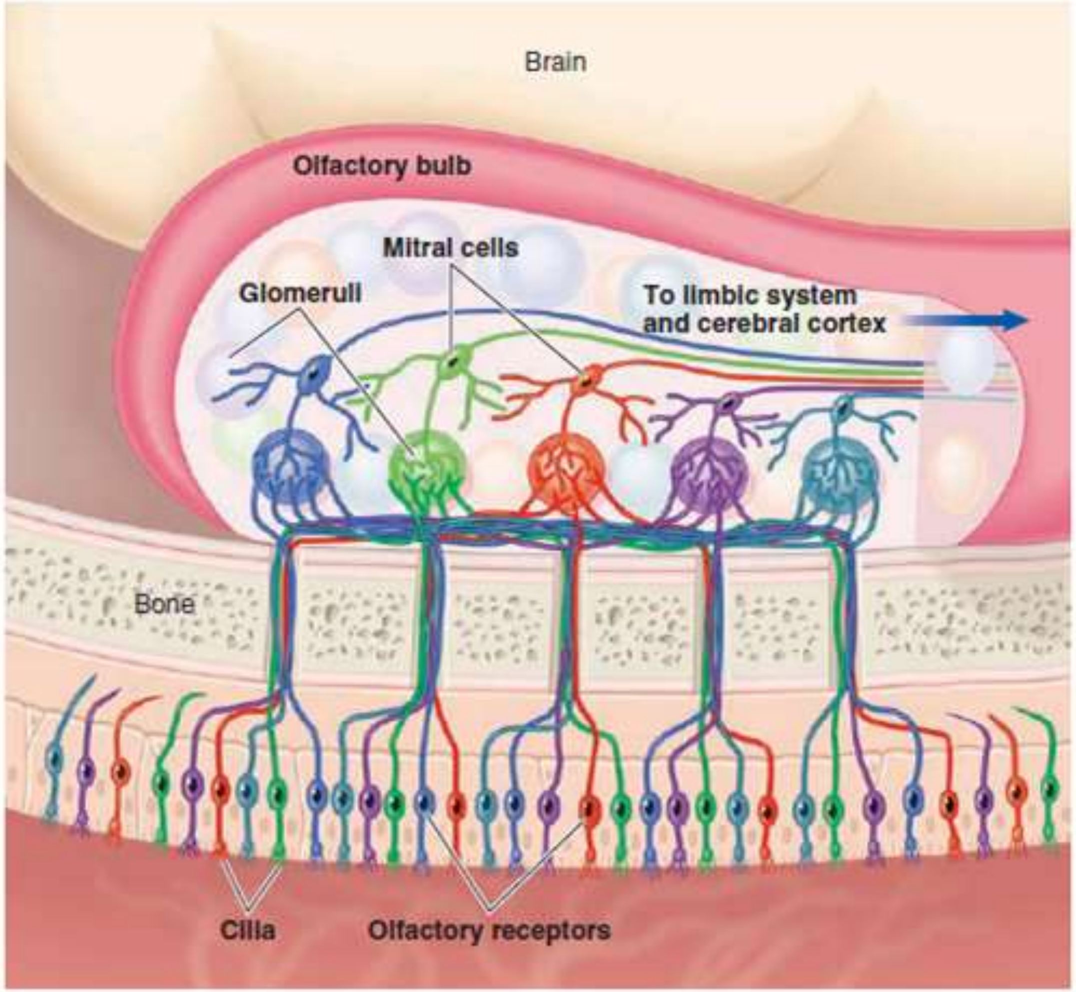


FIGURE 14–3 Basic neural circuits in the olfactory bulb. Note that olfactory receptor cells with one type of odorant receptor project to one olfactory glomerulus (OG) and olfactory receptor cells with another type of receptor project to a different olfactory glomerulus. CP, cribriform plate; PG, periglomerular cell; M, mitral cell; T, tufted cell; Gr, granule cell. (Modified from Mori K, Nagao H, Yoshihara Y: The olfactory bulb: Coding and processing of odor molecular information. Science 1999;286:711.)

Tanda panah tebal inhibisi (GABA)

Tanda panah putih eksitatorik (Glutamat)

- OG : dendrit sensorik sel T dan sel M membentuk unit-unit sinaps diskret
- PG : neuron inhibitorik menghubungkan satu glomerulus dgn glomerulus lainnya
- Gr :membentuk sinaps timbal-balik dgn sel M dan sel T

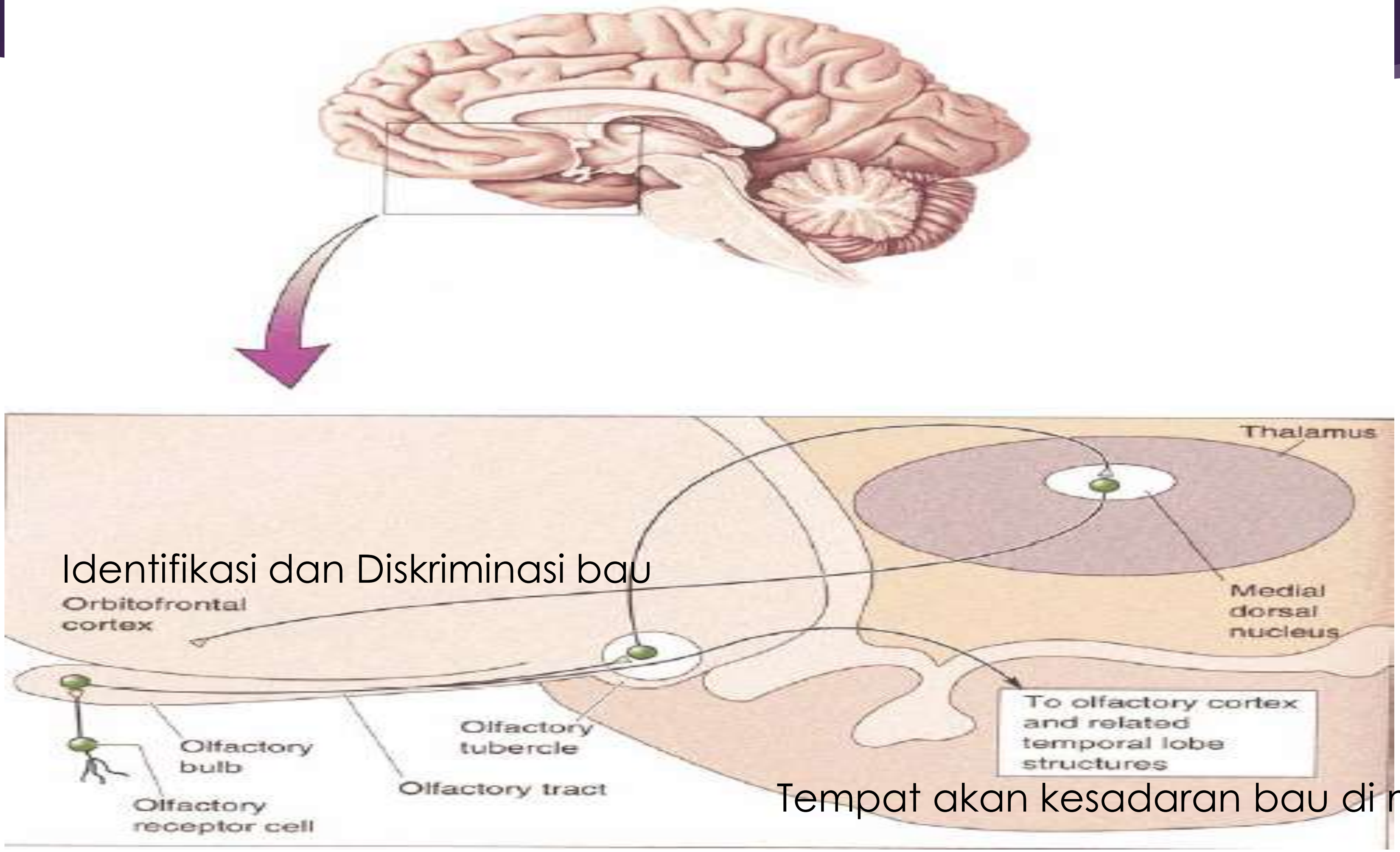


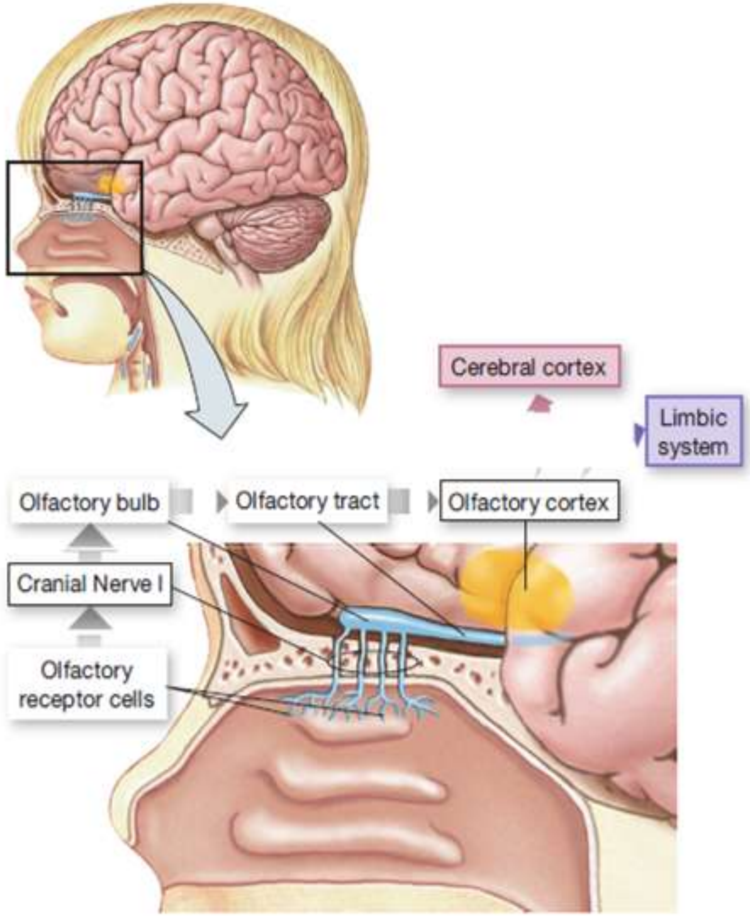
● **FIGURE 6-46 Processing of scents in the olfactory bulb.** Each of the glomeruli lining the olfactory bulb receives synaptic input from only one type of olfactory receptor, which, in turn, responds to only one discrete component of an odorant. Thus, the glomeruli sort and file the various components of an odoriferous molecule before relaying the smell signal to the mitral cells and higher brain levels for further processing.

Jaras Penciuman Sentral

- Sel reseptor penciuman msk olfactory bulb traktus olfactorius
- Setiap traktus olfaktorius menonjol secara langsung ke regio primitif korteks serebri kmd masuk thalamus neokorteks
- Rangkaian olfactori memberikan pengaruh yang luas dan langsung kpd bagian forebrain yang berperan dalam emosi, motivasi, memori tertentu
- Beberapa jaras paralel memidiasi fungsi olfaktori yang berbeda: penentuan bau, persepsi kesadaran, karakteristik emosi dan motivasi, behavior reproduksi dan makan, memori
- Persepsi kesadaran dari bau dimediasi oleh bagian dari olfactory tubercle menuju medial dorsal nucleus thalamus menuju korteks orbitofrontal.

Jaras Penciuman Sentral





● **FIGURE 10-15** *Olfactory pathways*

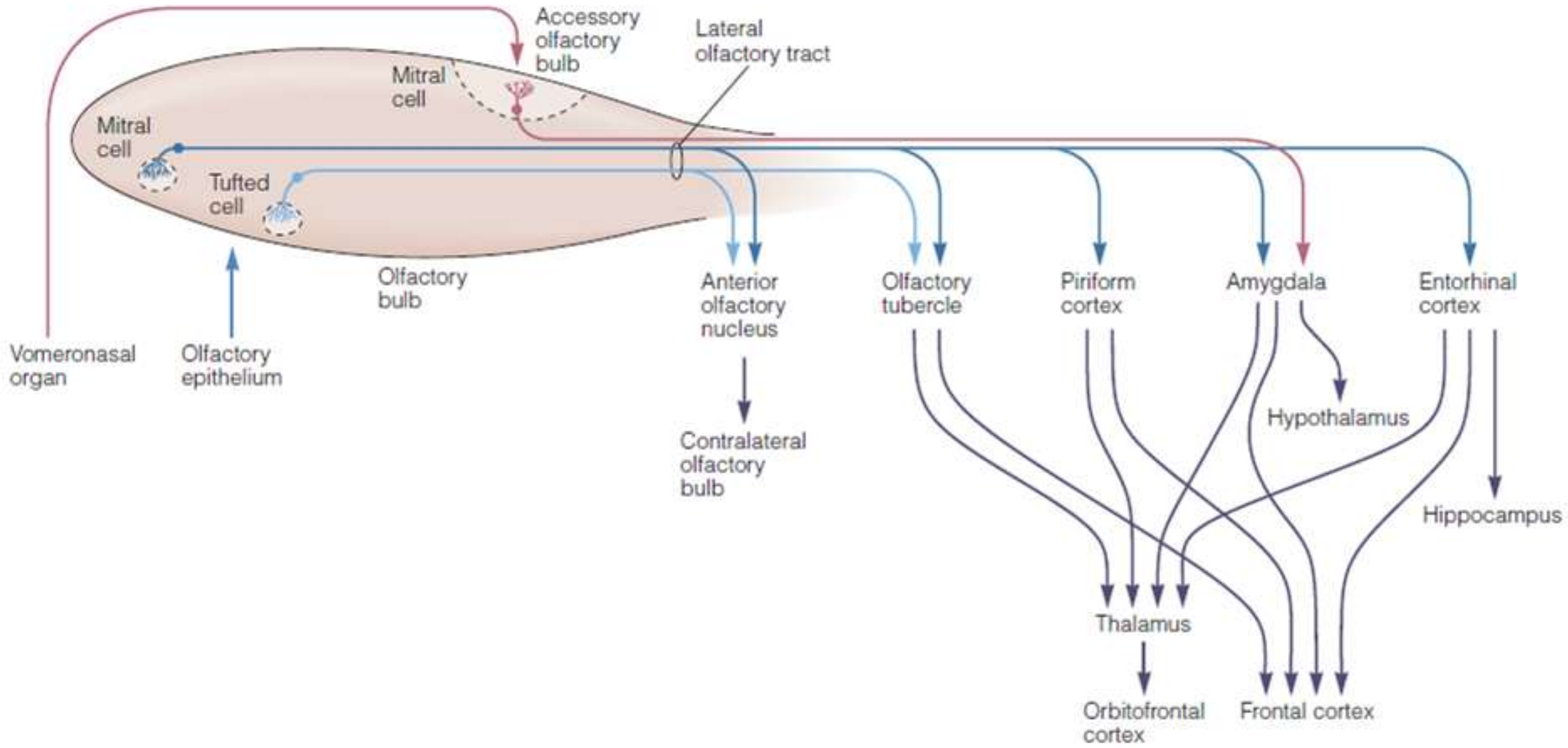
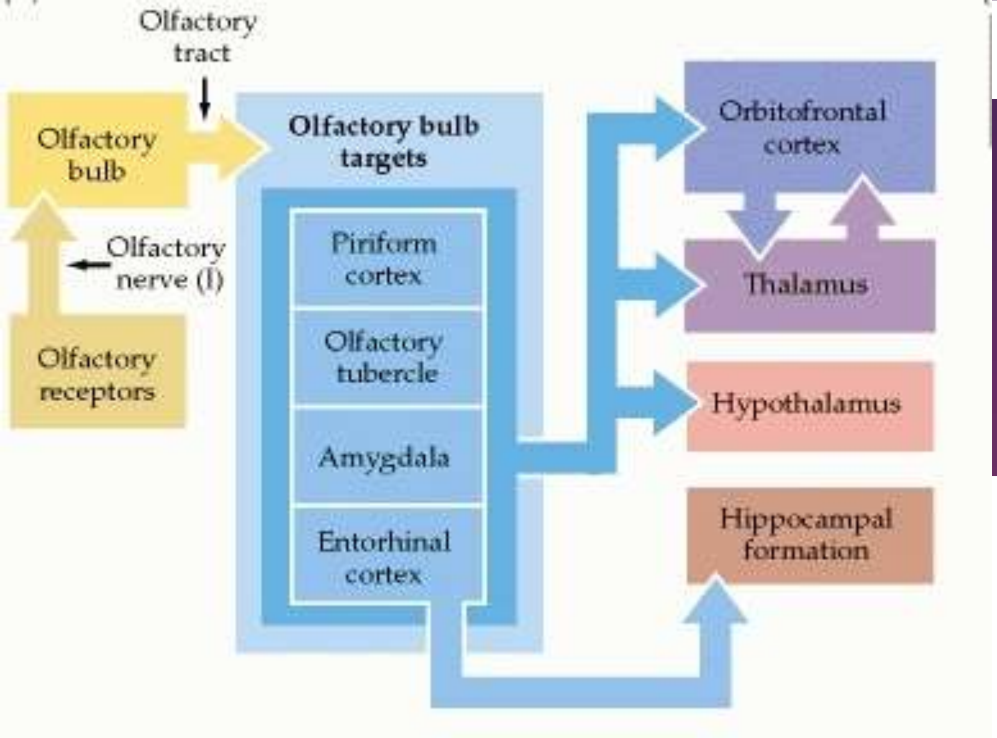
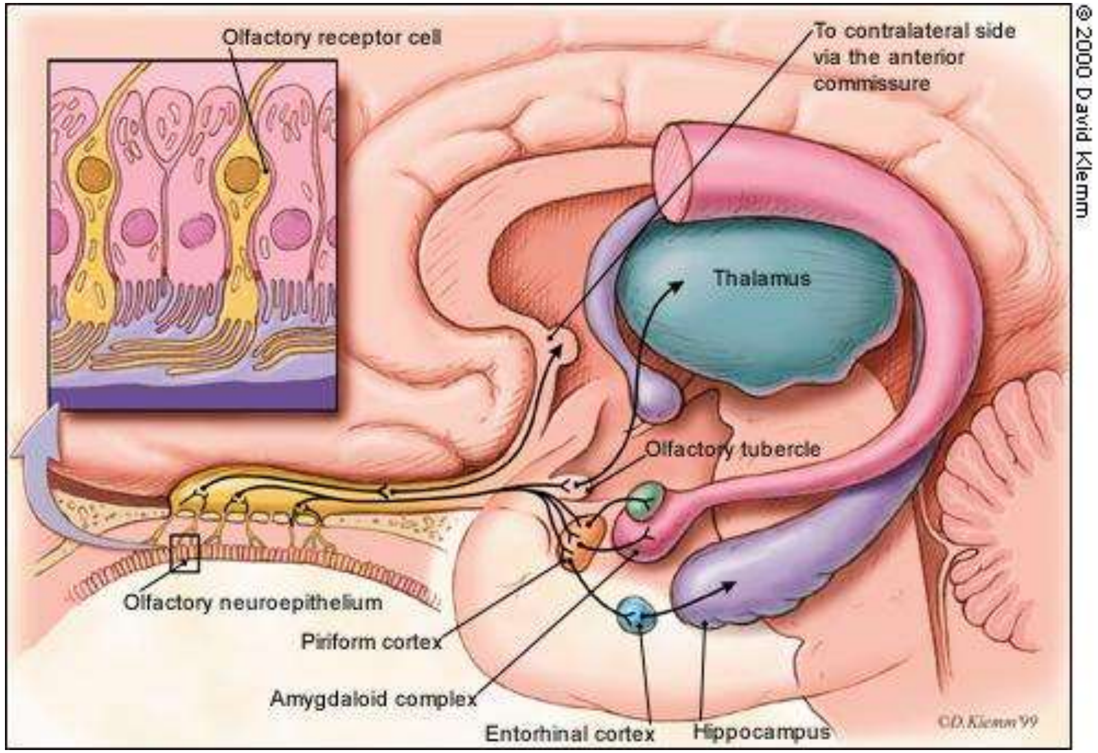


FIGURE 14–4 Diagram of the olfactory pathway. Information is transmitted from the olfactory bulb by axons of mitral and tufted relay neurons in the lateral olfactory tract. Mitral cells project to five regions of the olfactory cortex: anterior olfactory nucleus, olfactory tubercle, piriform cortex, and parts of the amygdala and entorhinal cortex. Tufted cells project to anterior olfactory nucleus and olfactory tubercle; mitral cells in the accessory olfactory bulb project only to the amygdala. Conscious discrimination of odor depends on the neocortex (orbitofrontal and frontal cortices). Emotive aspects of olfaction derive from limbic projections (amygdala and hypothalamus). (From Kandel ER, Schwartz JH, Jessell TM [editors]: *Principles of Neural Science*, 4th ed. McGraw-Hill, 2000.)



- Korteks piriformis : area utk mengidentifikasi bau
- Medial amygdala : terlibat dalam fungsi sosial
- Korteks enthorhinal :berhub dengan memori



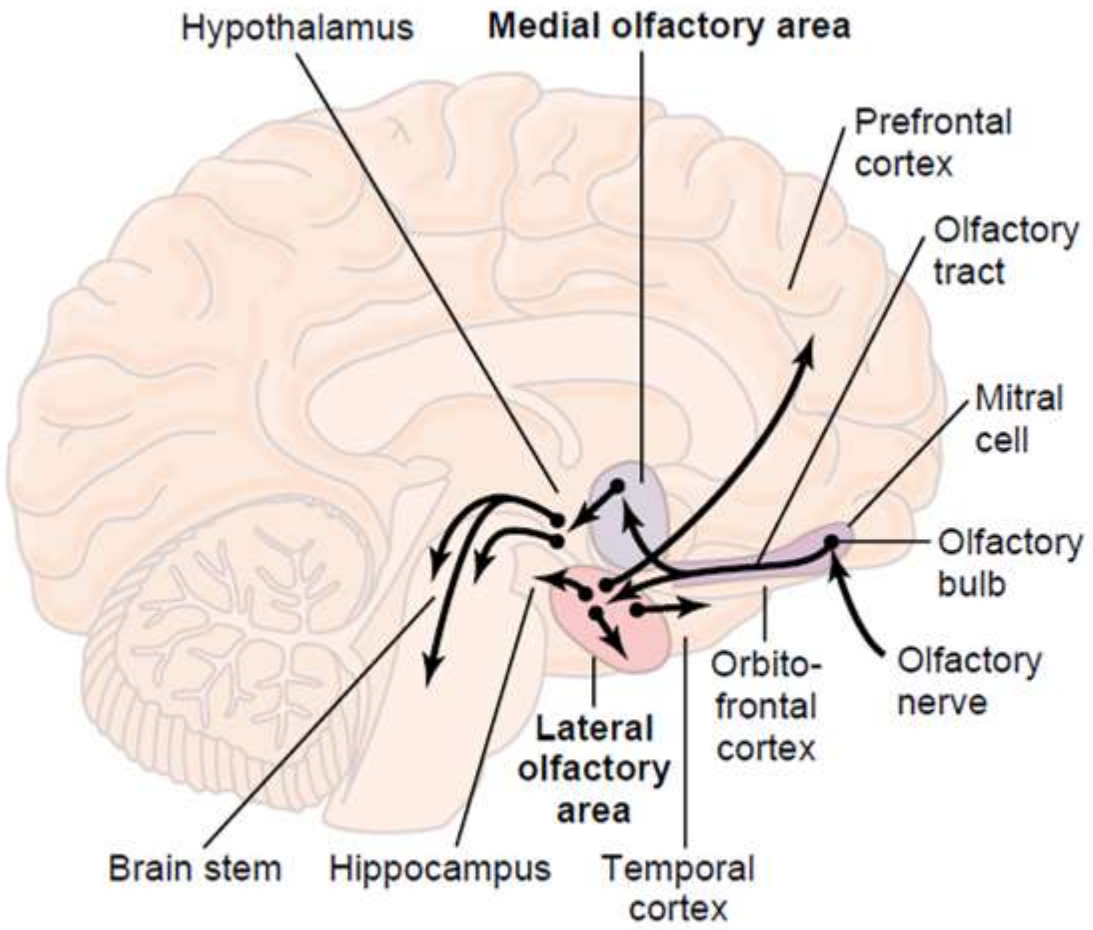


Figure 53–4

Neural connections of the olfactory system.

Anatomi sistem limbik digambarkan sebagai area yang berwarna

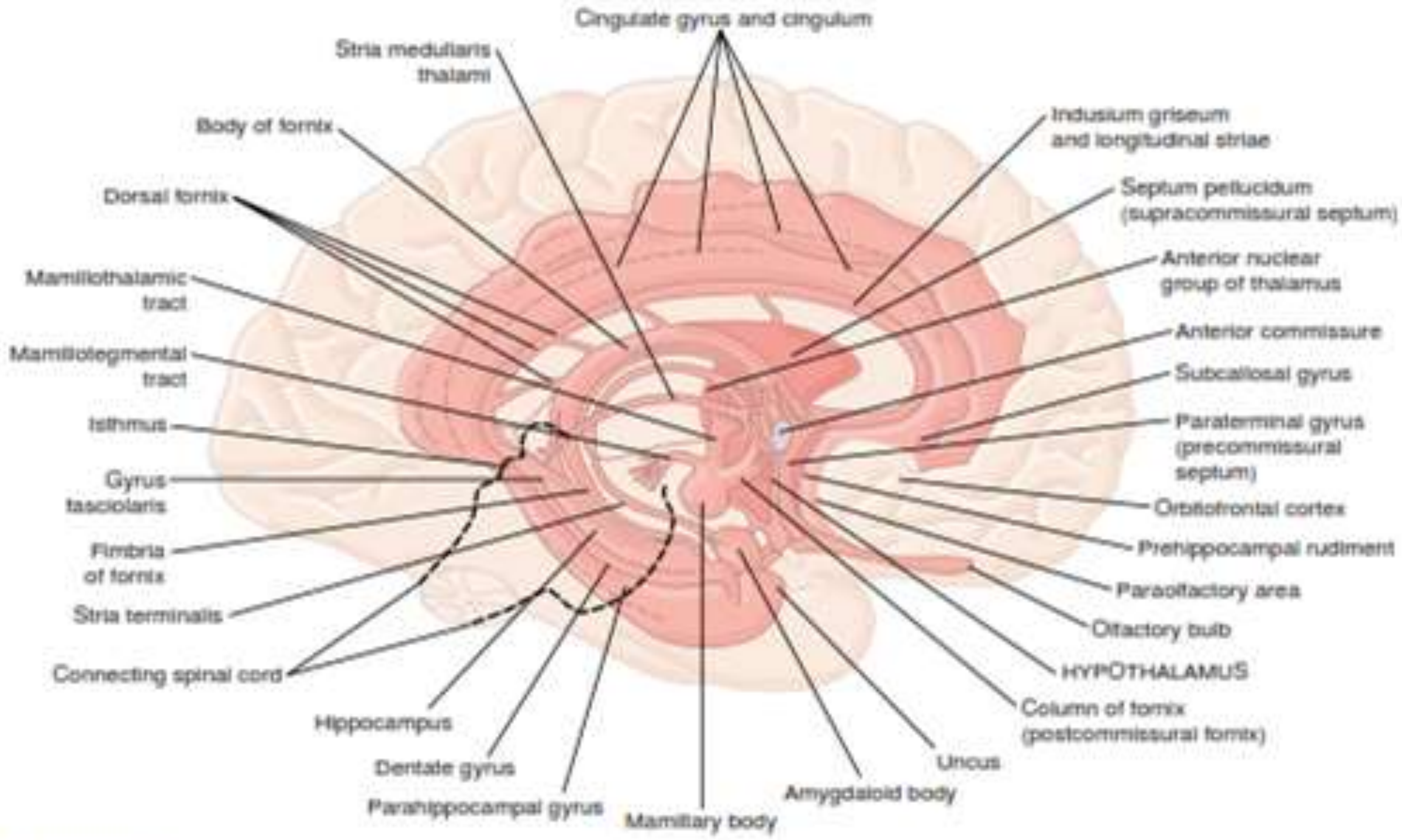
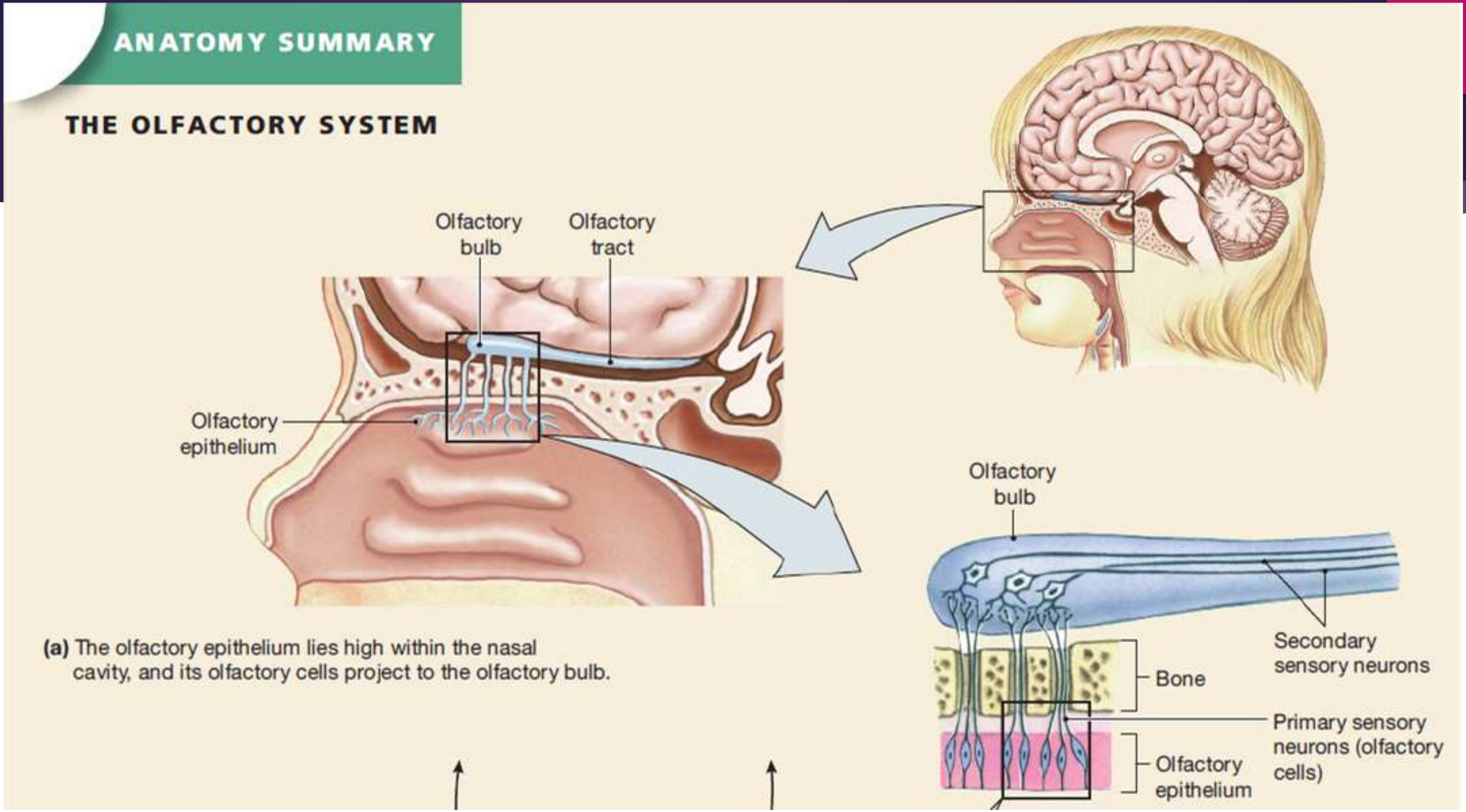
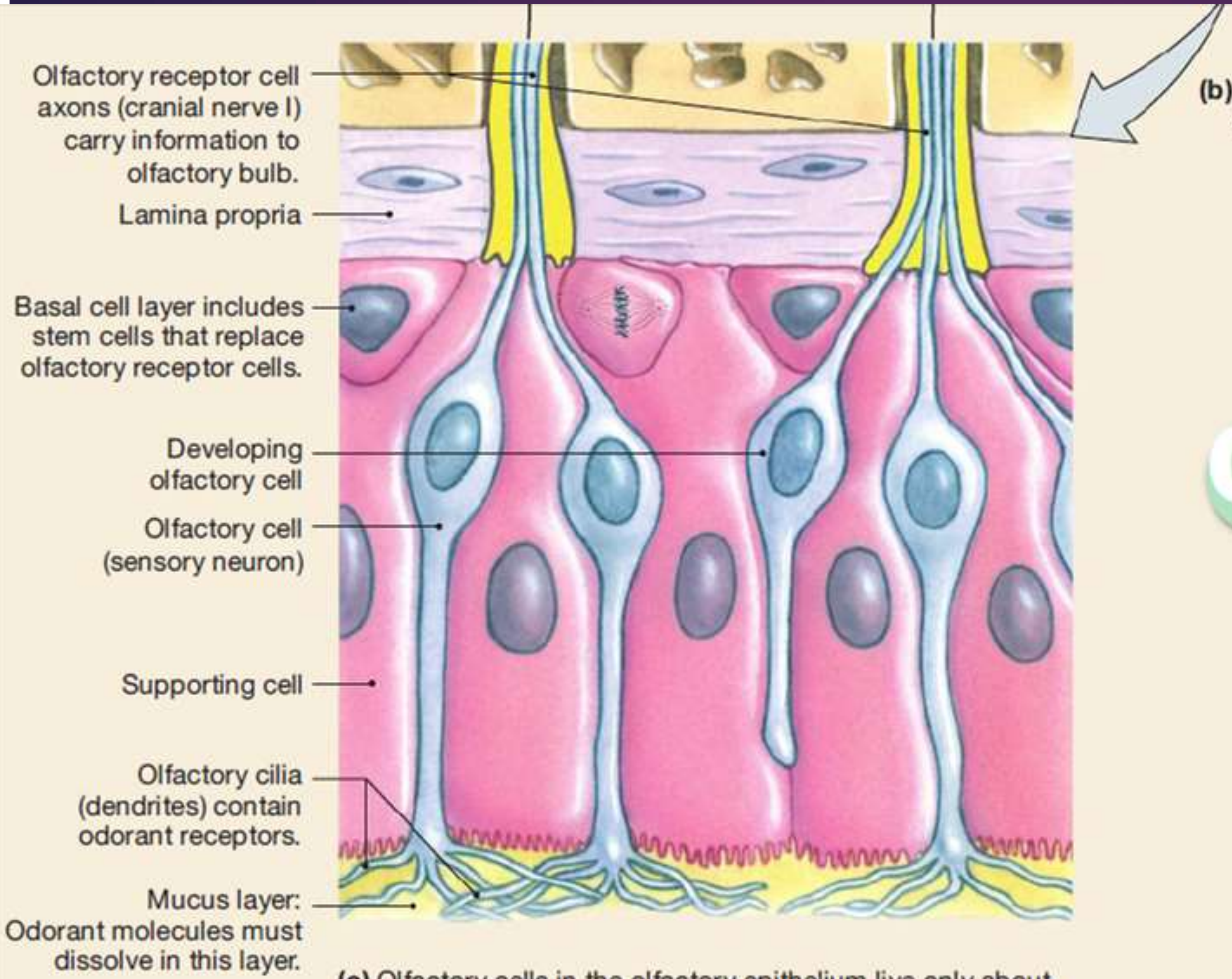


Figure 58-4

Anatomy of the limbic system, shown in the dark pink area. (Redrawn from Warwick R, Williams PL: Gray's Anatomy, 35th Br. ed. London: Longman Group Ltd, 1973.)



(a) The olfactory epithelium lies high within the nasal cavity, and its olfactory cells project to the olfactory bulb.



(b) The olfactory cells synapse with secondary sensory neurons in the olfactory bulb.

(c) Olfactory cells in the olfactory epithelium live only about two months. They are replaced by new cells whose axons must find their way to the olfactory bulb.

FIGURE QUESTION

Multiple primary neurons in the epithelium synapse on one secondary neuron in the olfactory bulb. This pattern is an example of what principle?

Pengecapan

RASA DASAR

5 rasa dasar:

- Asin
- Asam
- Manis
- Pahit
- Umami (artinya lezat dalam bahasa Jepang dihasilkan oleh asam amino glutamat/MSG

ORGAN PENGECAPAN

- Lidah Organ pengecapan yang utama

  Ujung lidah paling sensitif terhadap rasa manis, pangkal terhadap rasa pahit, sisi-sisnya terhadap rasa asin & asam; namun semua area lidah sensitif terhadap semua rasa dasar

- Palatum
- Faring
- Epiglotis

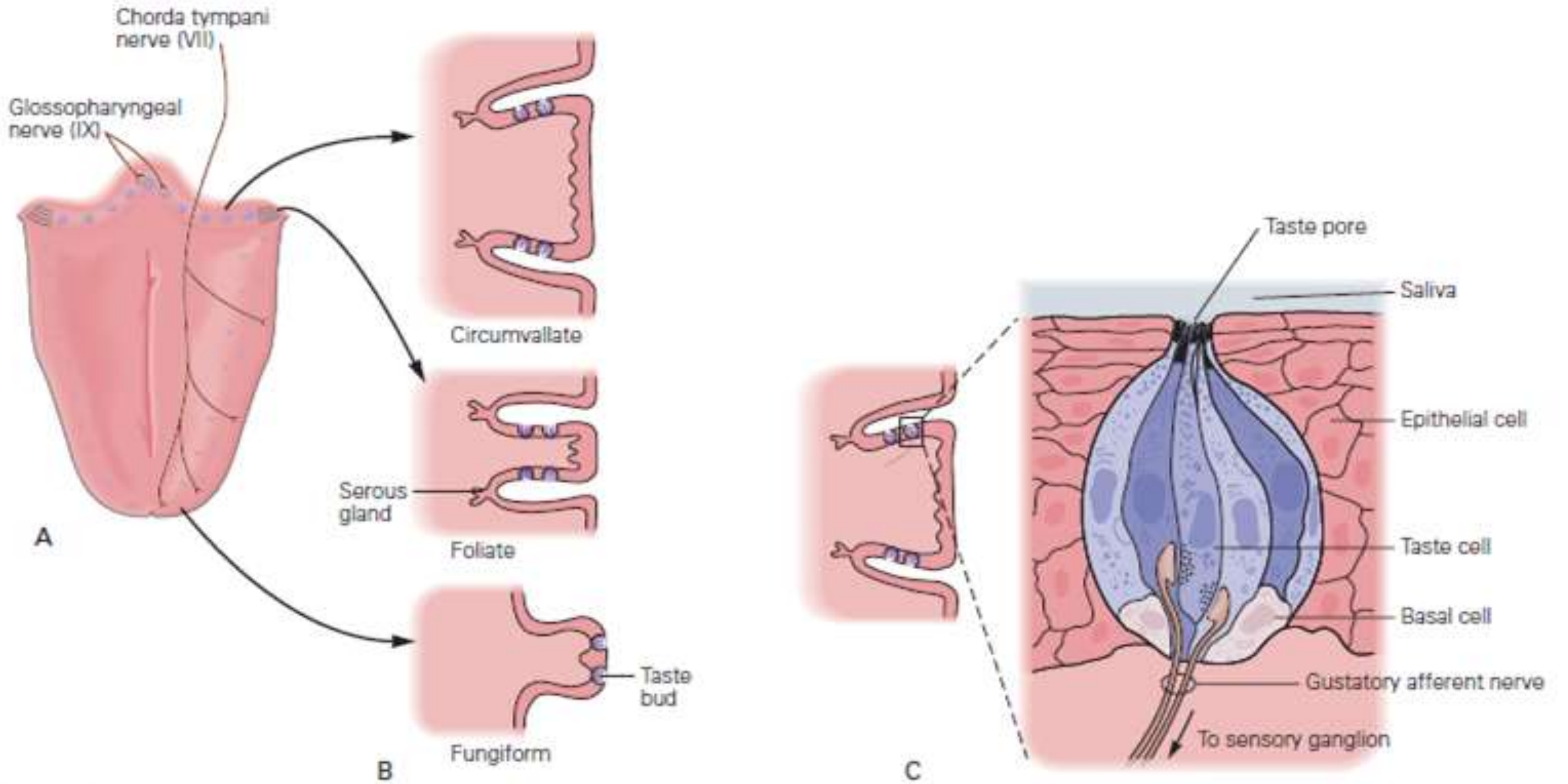


FIGURE 14–6 Taste buds located in papillae of the human tongue. A) Taste buds on the anterior two-thirds of the tongue are innervated by the chorda tympani branch of the facial nerve; those on the posterior one-third of the tongue are innervated by the lingual branch of the glossopharyngeal nerve. **B)** The three major types of papillae (circumvallate, foliate, and fungiform) are located on specific parts of the tongue. **C)** Taste buds are composed of basal stem cells and three types of taste cells (dark, light, and intermediate). Taste cells extend from the base of the taste bud to the taste pore, where microvilli contact tastants dissolved in saliva and mucus. (Modified from Kandel ER, Schwartz JH, Jessell TM [editors]: *Principles of Neural Science*, 4th ed. McGraw-Hill, 2000.)

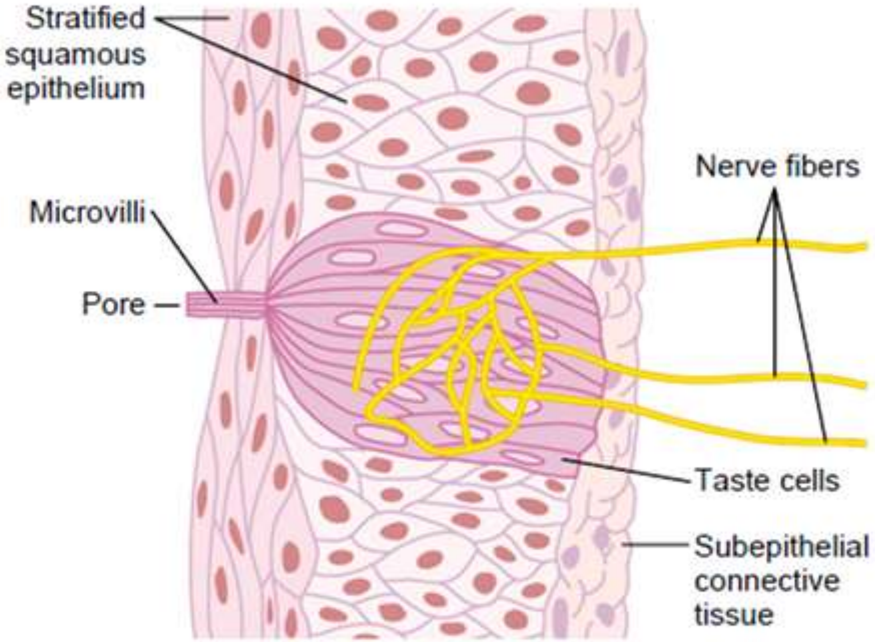


Figure 53–1

Taste bud.

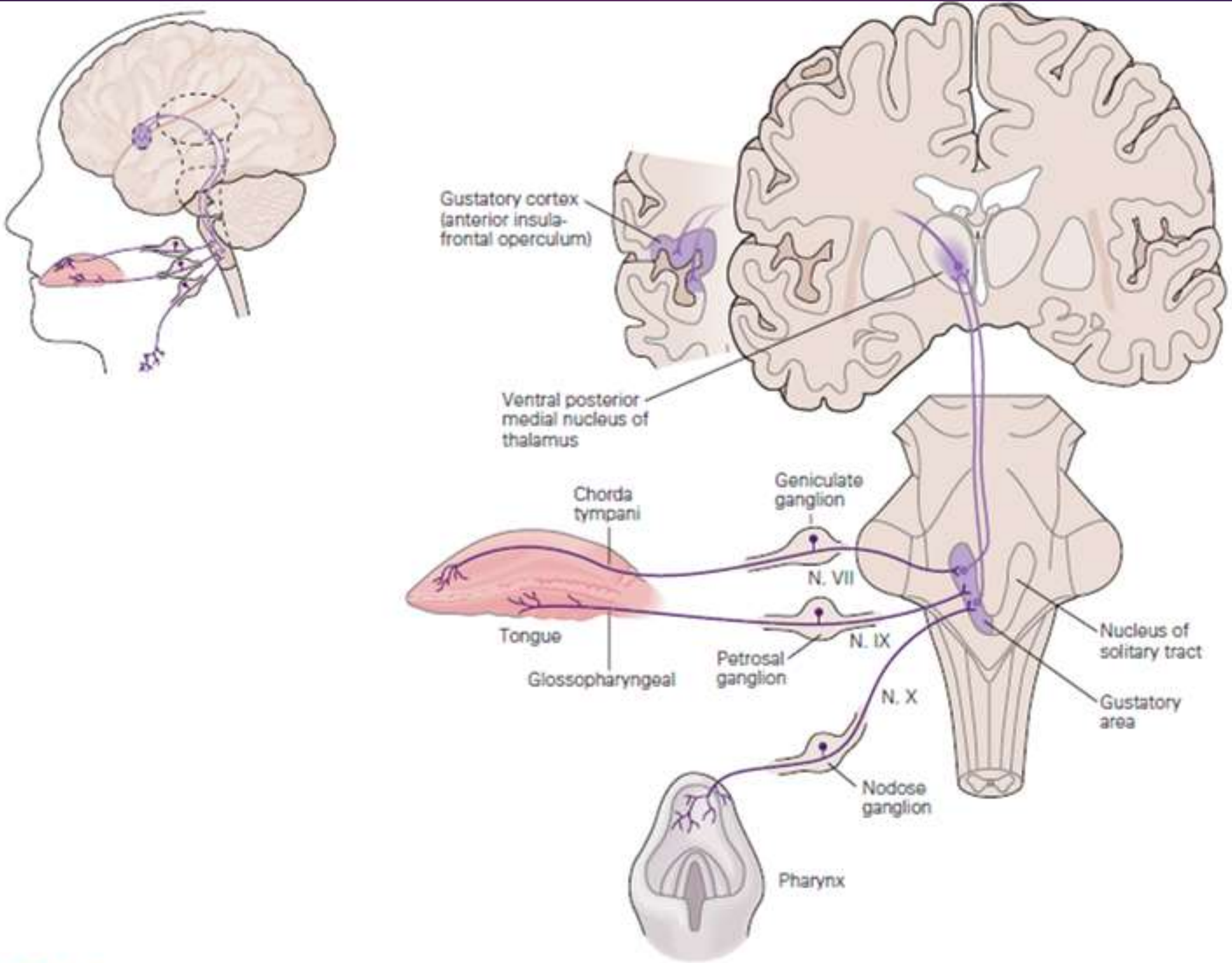


FIGURE 14–7 Diagram of taste pathways. Signals from the taste buds travel via different nerves to gustatory areas of the nucleus of the solitary tract which relays information to the thalamus; the thalamus projects to the gustatory cortex. (Modified from Kandel ER, Schwartz JH, Jessell TM [editors]: *Principles of Neural Science*, 4th ed. McGraw-Hill, 2000.)

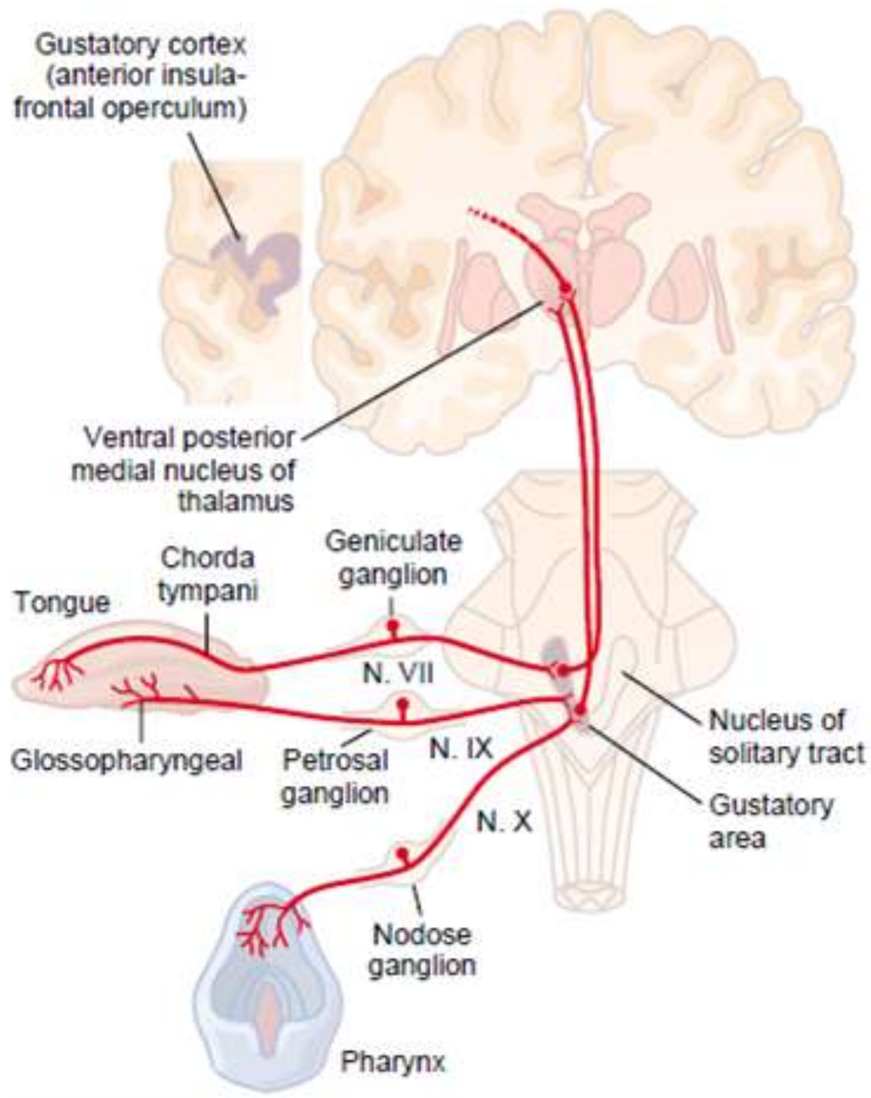


Figure 53–2

Transmission of taste signals into the central nervous system.

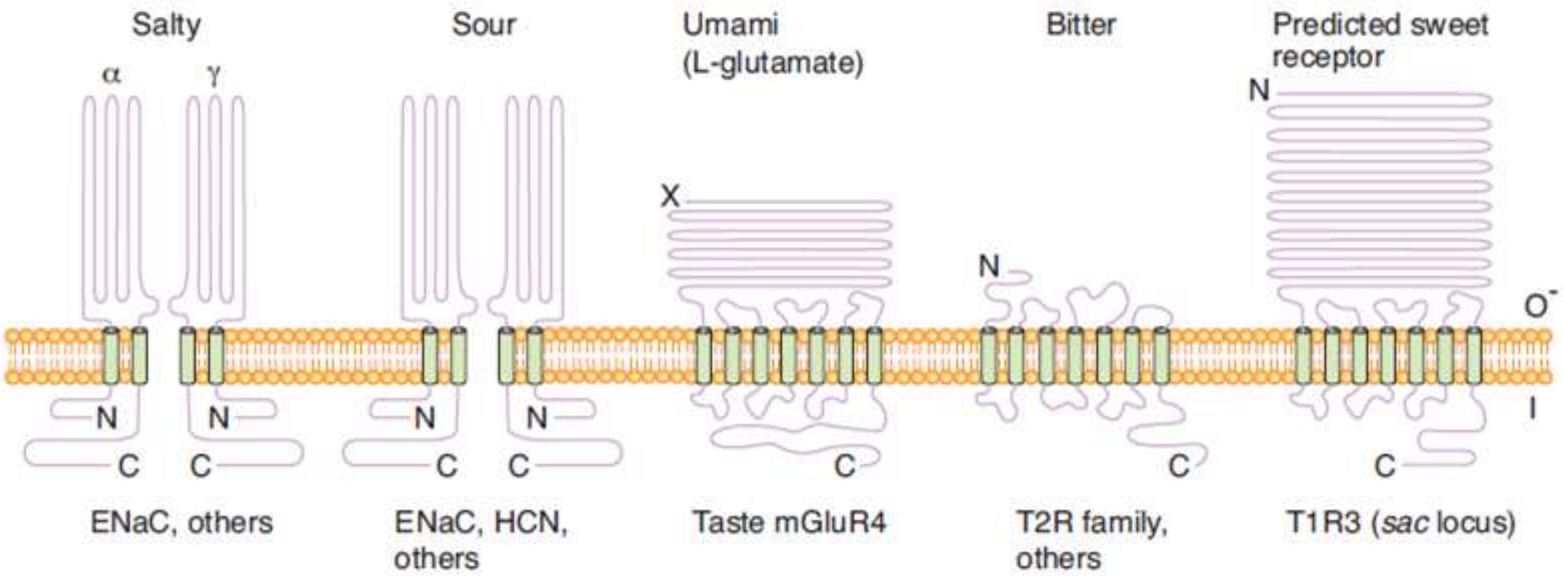


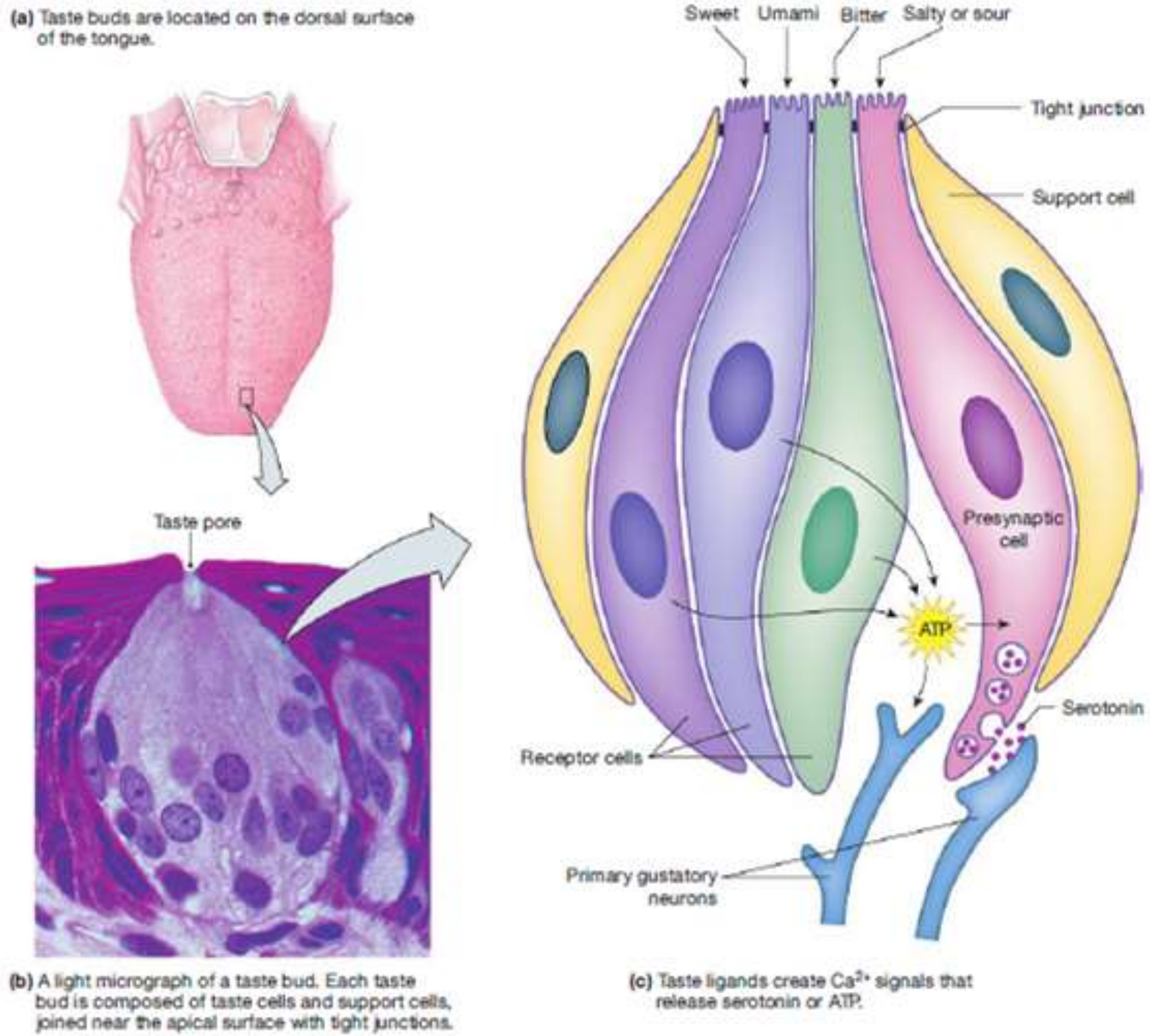
FIGURE 14–8 Signal transduction in taste receptors. Salt-sensitive taste is mediated by a Na^+-selective channel (ENaC); sour taste is mediated by H^+ ions permeable to ENaCs; umami taste is mediated by glutamate acting on a metabotropic receptor, mGluR4; bitter taste is mediated by the T2R family of G protein-coupled receptors; sweet taste may be dependent on the T1R3 family of G protein-coupled receptors which couple to the G protein gustducin. (Modified from Lindemann B: Receptors and transduction in taste. Nature 2001;413:219.)

Table 53–1

Relative Taste Indices of Different Substances

Sour Substances	Index	Bitter Substances	Index	Sweet Substances	Index	Salty Substances	Index
Hydrochloric acid	1	Quinine	1	Sucrose	1	NaCl	1
Formic acid	1.1	Brucine	11	1-Propoxy-2-amino-4-nitrobenzene	5000	NaF	2
Chloracetic acid	0.9	Strychnine	3.1			$CaCl_2$	1
Acetylacetic acid	0.85	Nicotine	1.3	Saccharin	675	NaBr	0.4
Lactic acid	0.85	Phenylthiourea	0.9	Chloroform	40	NaI	0.35
Tartaric acid	0.7	Caffeine	0.4	Fructose	1.7	LiCl	0.4
Malic acid	0.6	Veratrine	0.2	Alanine	1.3	NH_4Cl	2.5
Potassium H tartrate	0.58	Pilocarpine	0.16	Glucose	0.8	KCl	0.6
Acetic acid	0.55	Atropine	0.13	Maltose	0.45		
Citric acid	0.46	Cocaine	0.02	Galactose	0.32		
Carbonic acid	0.06	Morphine	0.02	Lactose	0.3		

From Pfaffman C: Handbook of Physiology. Sec I, Vol 1. Baltimore: Williams & Wilkins, 1959, p. 507.



● **FIGURE 10-16** *Taste buds are composed of taste cells and support cells.*

Part (c) adapted from Tomchik *et al.*, *J. Neuroscience* 27 (40): 10840–10848, 2007.

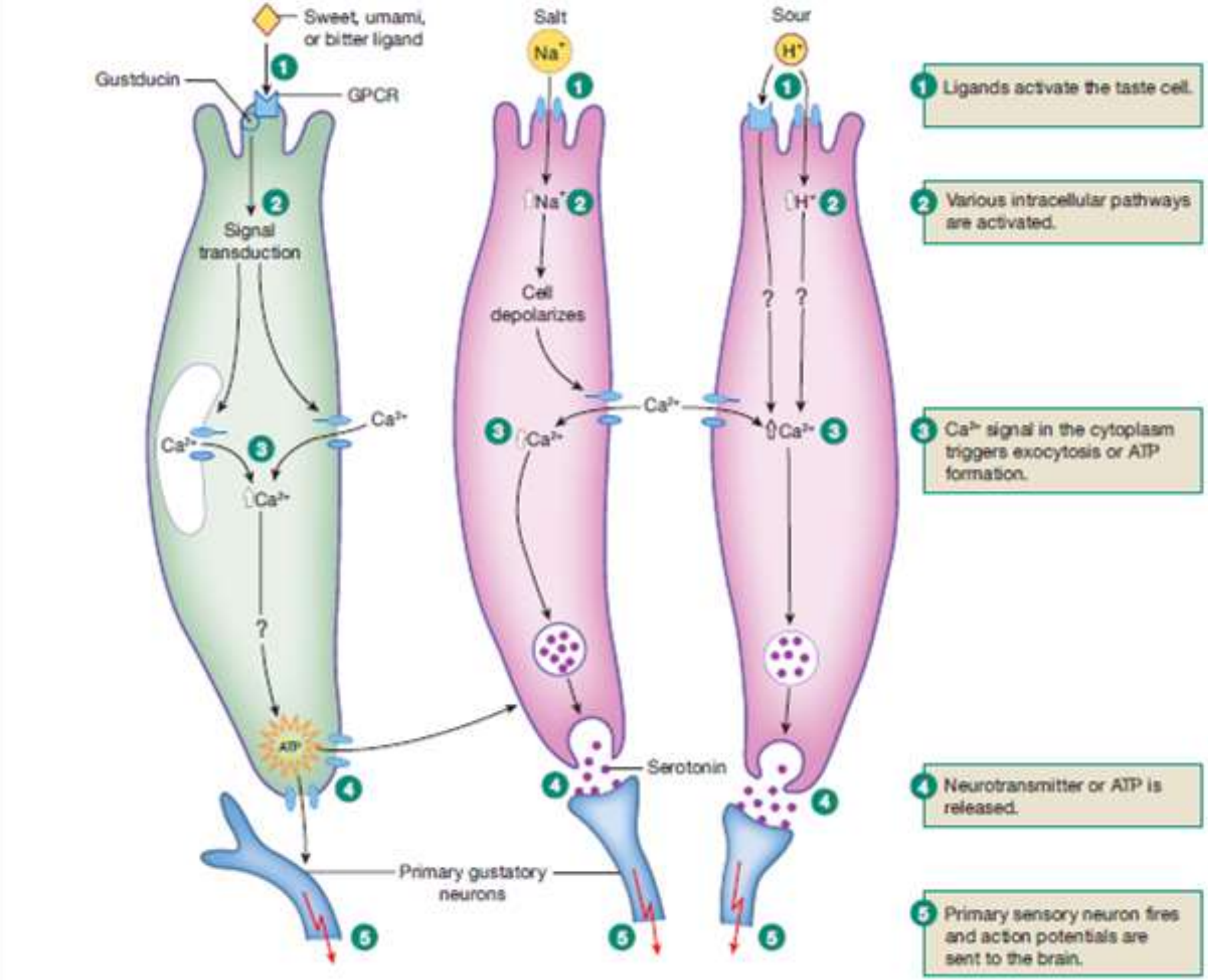


FIGURE 10-17 ***Summary of taste transduction.*** Each taste cell senses only one type of ligand. Receptor cells with G protein–coupled membrane receptors bind either bitter, sweet, or umami ligands and release ATP as a signal molecule. Sodium ion for salt taste enters presynaptic cells through ion channels and triggers exocytosis of serotonin. It is unclear whether H^+ for sour taste acts intracellularly or extracellularly.