

The Link Between Olfaction and Emotions

Activities Unlimited
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About Me

- Ph.D. in Experimental Psychology 1981
- Faculty at Fordham University Graduate School of Arts & Sciences 1981 - 1987
- Colgate-Palmolive R&D Senior Research Scientist 1987 – 1994
- Givaudan-Roure Global Research Director of Insights 1994-1998
- Takasago International Corporate (Global) VP Insights 1998-2014

Overview

- Background and Terminology
- Olfactive Neurological System
- Limbic System (emotions)
- My career
- Perfumery

Monell Chemical Senses

- The research of smell is a very young science
- Requires multidisciplinary teams
- Monell Chemical Senses is a major center for advancement:
 - Experimental Psychology
 - Biochemistry
 - Microbiology
 - Neurophysiology
 - Genetics
 - Biophysics



Olfactory Function

- Chemical senses (smell and taste) are important for human safety, nutrition, and quality of life.
- The sense of smell is a long distance and a short distance sensory system and can:
 - Finding food
 - Protect us from eating spoiled/poisoned food
 - Detecting predators
 - Navigating
 - (Finding a mate)

Basic Theories of Olfaction

- ***Shape Theory***: BUT: humans can detect many more smells than there are odorant receptors. Also, it cannot explain how two chemicals, each with a unique shape, can smell essentially the same.
- ***Vibrational Theory*** (R.H., 1937)
- ***Molecular vibrations together with the molecular shape*** (Luca Turin, 1996). Hence, two chemicals with identical shapes but markedly different molecular vibrations would have distinct smells. None of the human subjects could tell the difference.

An Odorant/Scent/Aroma

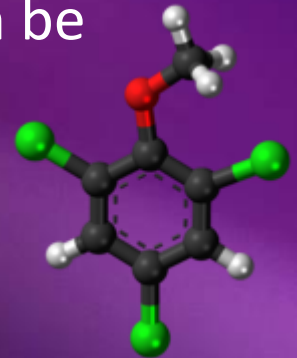
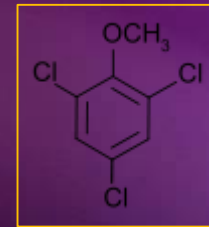
- In order for you to smell something, molecules from that has to make it to your nose.
- Everything you smell, therefore, expelling molecules -- whether it is bread in the bakery, onions, perfume, a piece of fruit or whatever.
- Those molecules are generally volatile, easy to evaporate. A piece of steel has no smell because nothing evaporates from it – unless you heat the steel.

Sensitivity

There are many volatile compounds that can evoke an olfactive sensation at extremely low levels.

● TCA

- 2,4,6-trichloroanisole is a very interesting culprit - a foul, musty smell (moldy)
- The sensory threshold for TCA of wine experts can be measured in the *parts per trillion*.



● Malodors

- *Most malodors have very low detection levels (i.e., thresholds)*

Masking Agents

- Masking: obscuring or blocking one sensory sensation by another.
- TCA is a masking agent by suppressing cyclic nucleotide-gated channels (CNG) of primary receptors cells. Hence. The chemical signal (odorants) are not translated into electrical signals (neurons).
- Takasago paid over \$500,000 to discover more masking agents.

Sensory Adaptation

- Repeated or prolonged exposure to an odorant leads to a decrease in sensitivity to that odorant.
- The magnitude of the decrease and the time course of adaptation and recovery are dependent on the concentration of the odor and on the duration of exposure.
- Compared to other sensory systems, adaptation in olfaction has been shown to be very long-lasting.
- Peripheral and/or central?

Dual Barrel

- Due to olfactory sensory adaptation, home fragrance devices can alternate scents, e.g., dual chamber plug-ins.



Malodor

- Circular definition: A malodor is an unpleasant odor in intensity and/or quality.
- Very low detection thresholds – very high sensitivity (danger/danger/danger).
- Some malodors are also irritants.
- Sensory adaptation is minimal.

The Nose Knows?

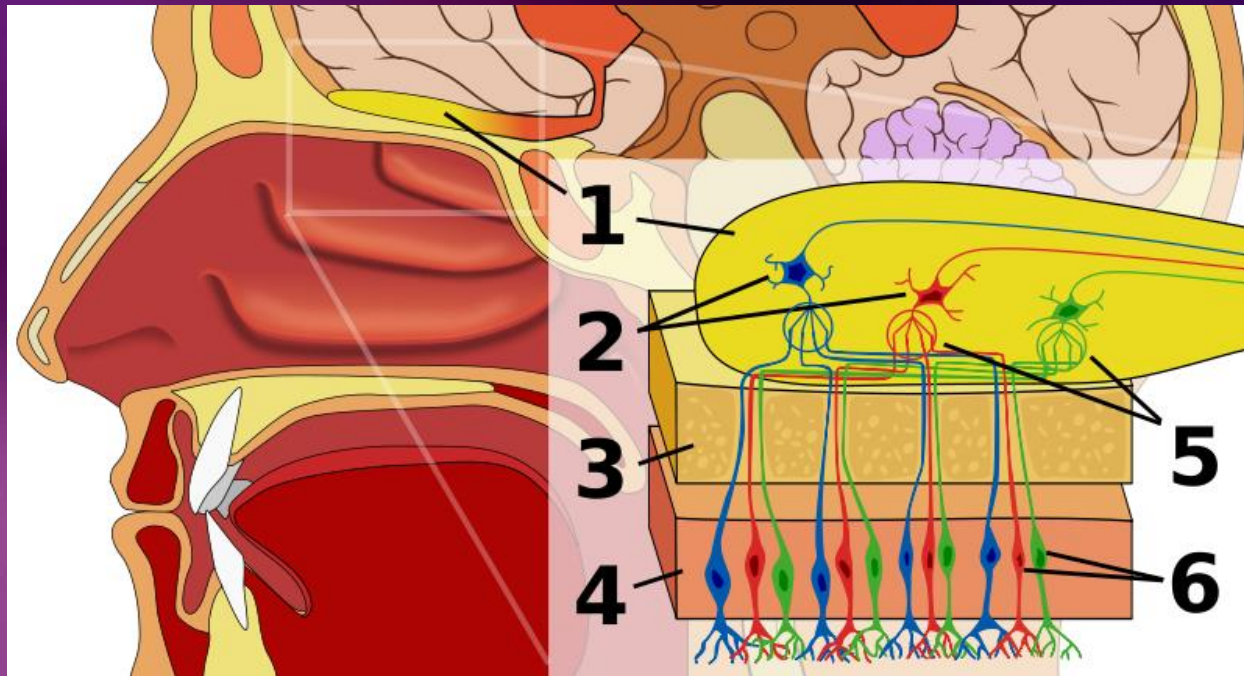


Nares Alternate
Swelling

Human Primary Receptors

- Vision has two types of receptors – rods (120 million cells) and cones (6 million cells):
 - Cones have three types of receptors (red, green, blue)
 - Rods have one type of receptors
- Taste has five primary receptors – Sweet, Bitter, Sour, Salty and Umami
- Olfaction has about 4 Million

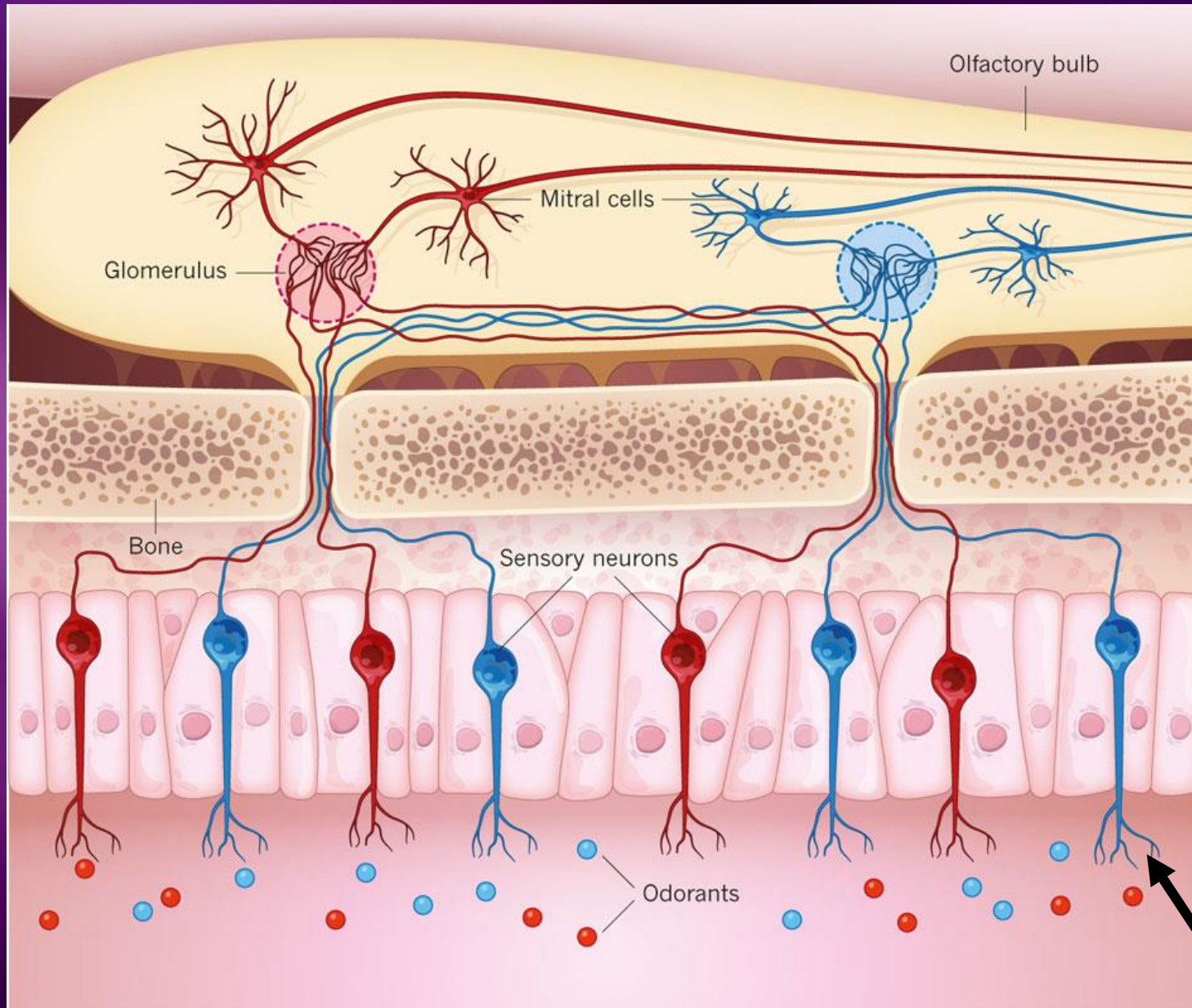
Initial Olfactory System



- 1: Olfactory bulb
- 2: Mitral cells
- 3: Bone
- 4: Nasal epithelium
- 5: Glomerulus (olfaction)
- 6: Olfactory receptor cells.

30 Day
Cycle

Initial Olfactory Organization



30 Day
Cycle

Olfactory Bulb

- The organization of the olfactory pathways is highly complex and not yet well understood.
- Olfactory receptors located in the same zone of the mucosa send their information to the same glomeruli.
- Any particular olfactory receptor neuron will only send a message to a maximum of two glomeruli.

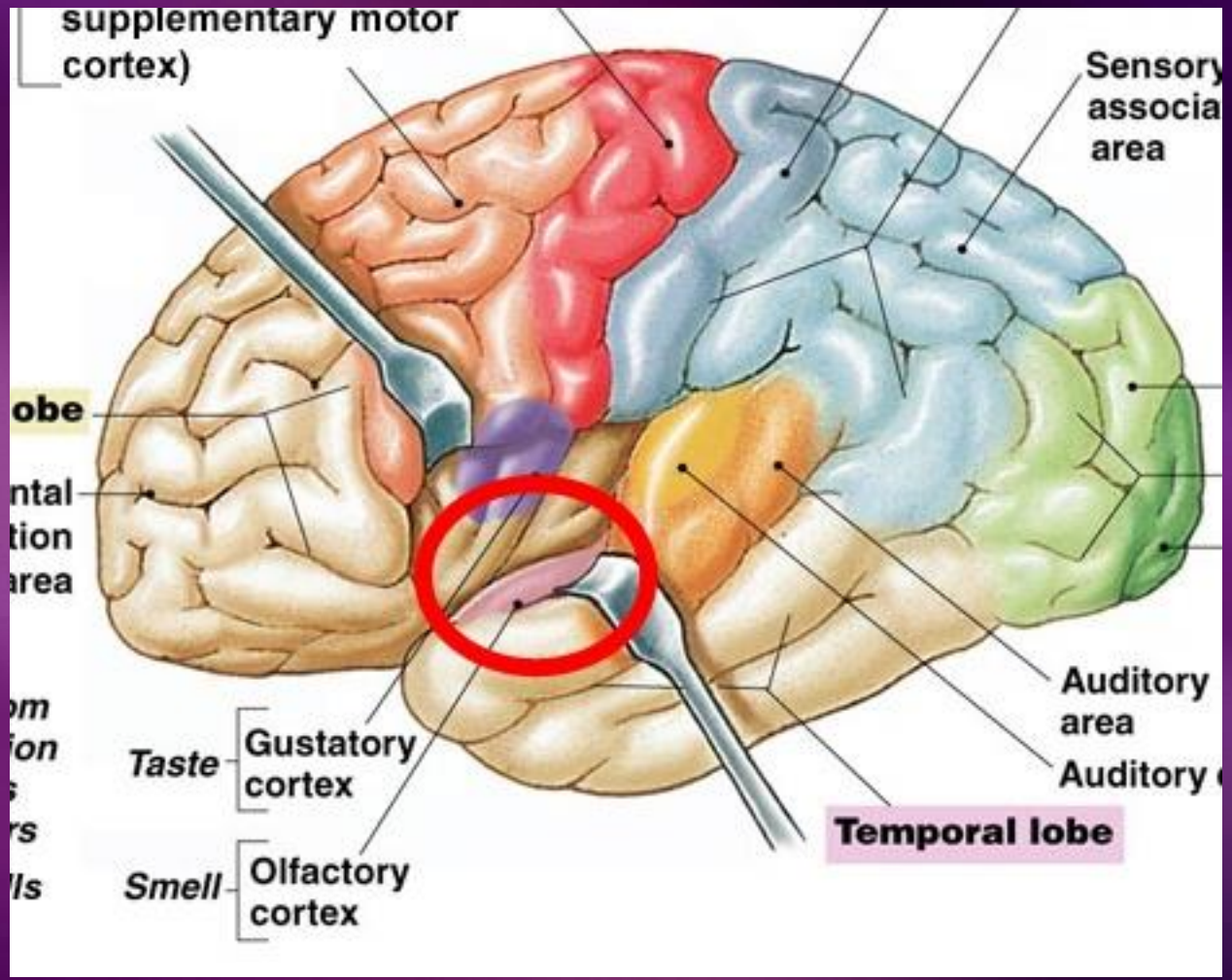
Olfactory System (sense of smell)

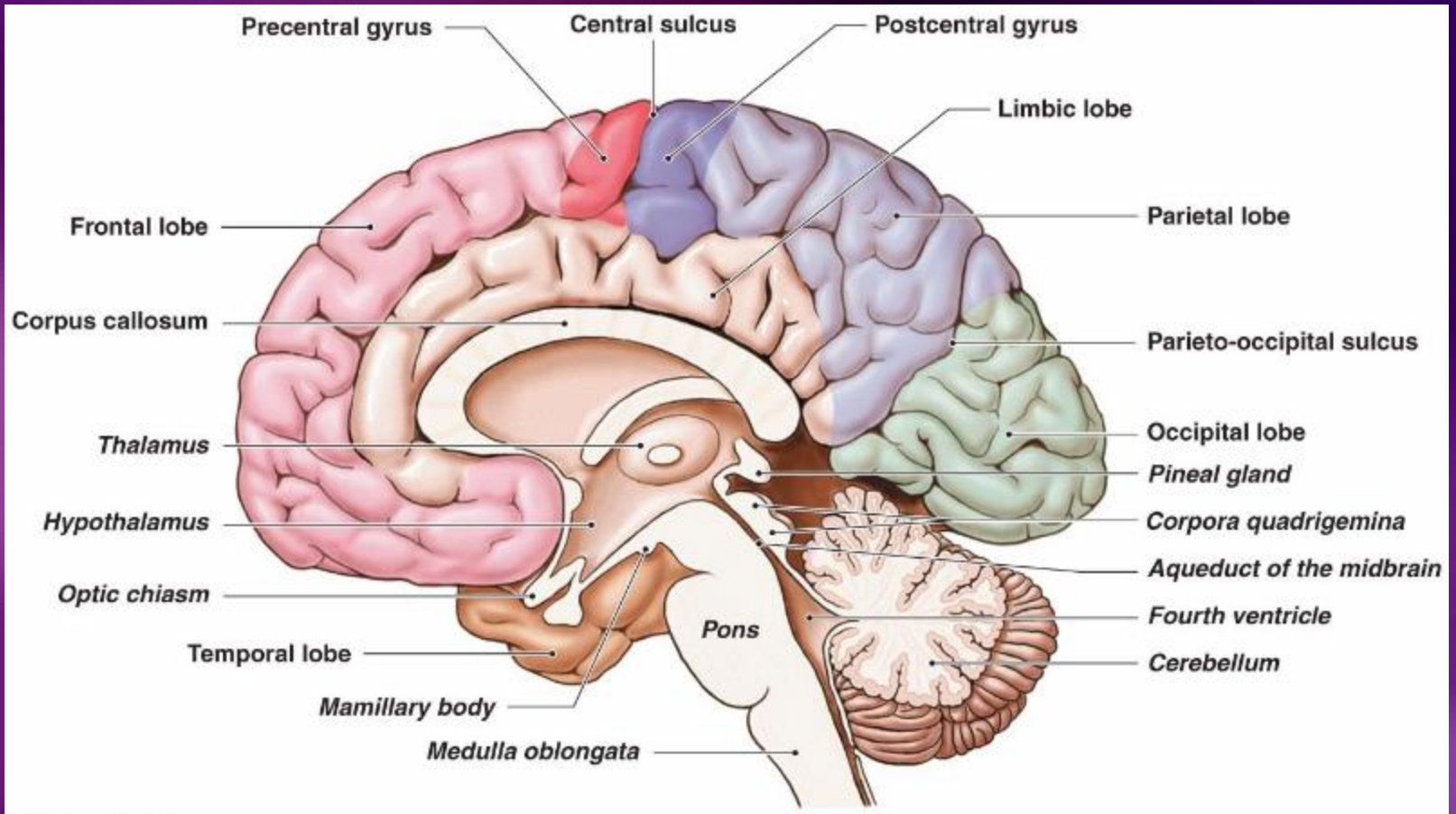
Limbic System (modulates emotions)

Overlap?
Integration?

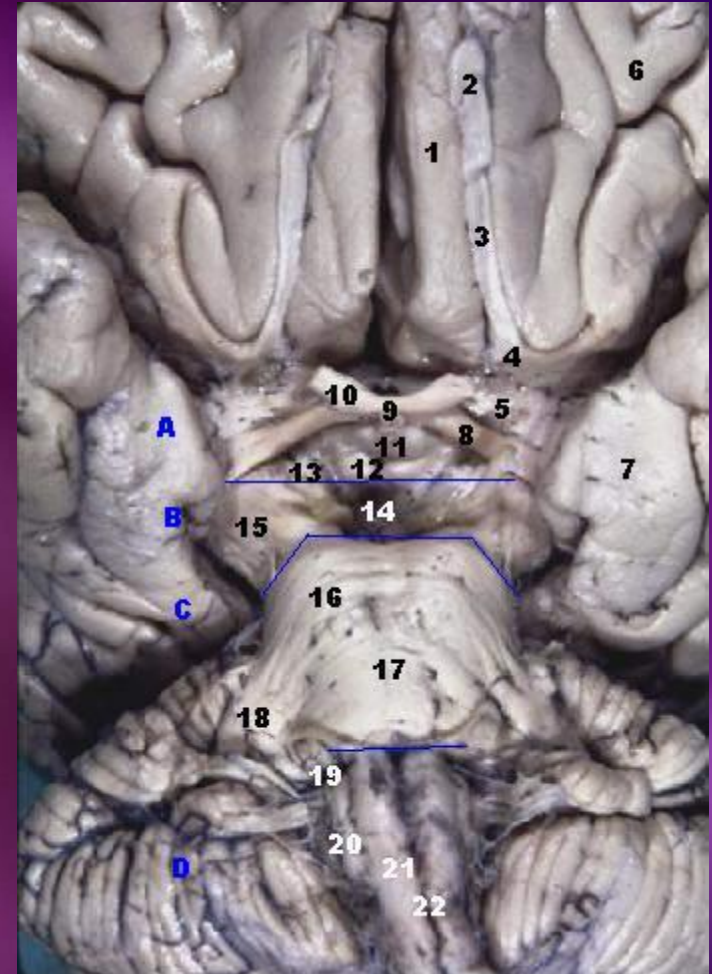
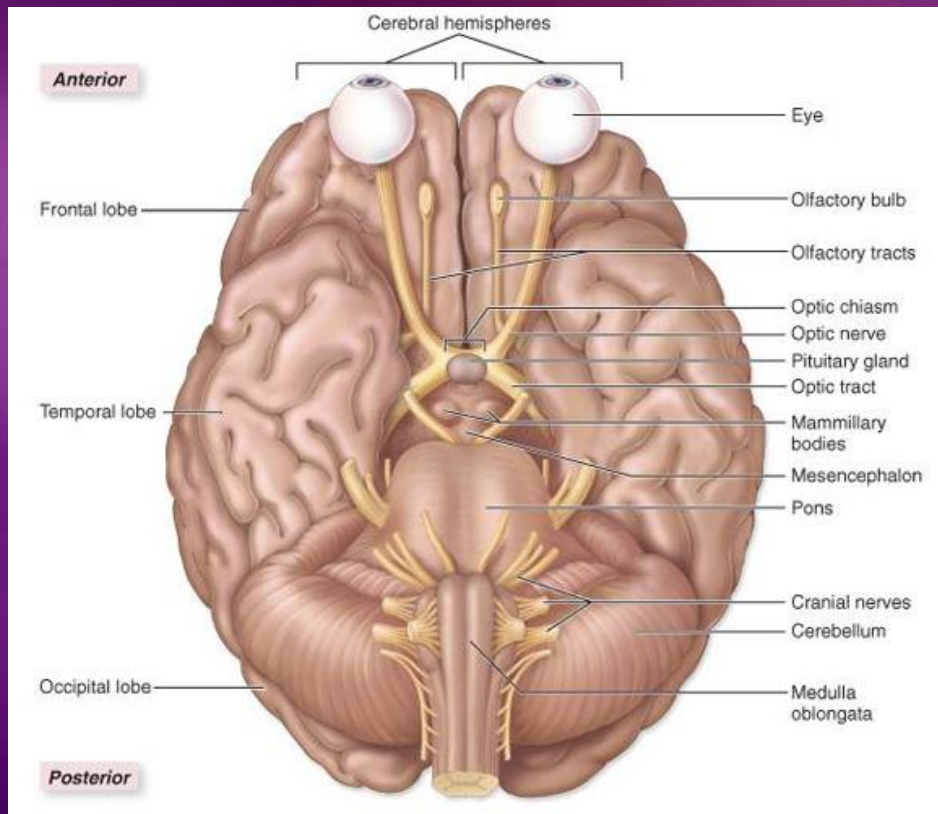
Human Brain







Ventral View of Brain



Olfactory Brain Pathways

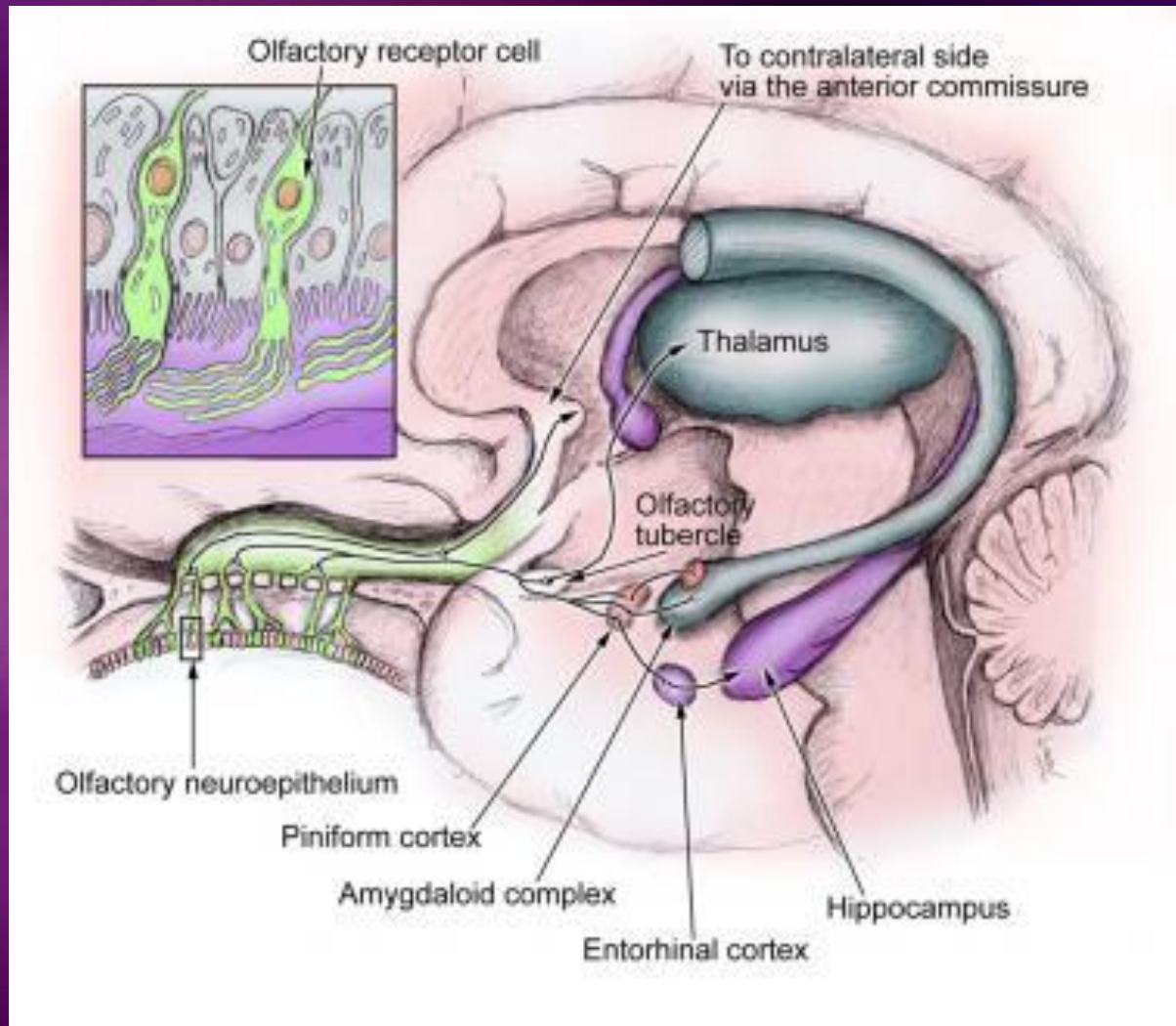
Conscious (Perception)

- The lateral olfactory tracts innervate the **piriform cortex**. From there, it goes to the **thalamus** (sensory and motor signal relay, regulation of consciousness and sleep) and **orbito-frontal cortex** (conscious smell occurs).

Unconscious (Emotion)

- The olfactory tracts also innervate the **amygdala** (emotions) and then on to the **hypothalamus** (homeostatic systems). Both are part of **the limbic system**.
- The **limbic system** is involved in the “emotional” component of smell.

Olfactory Brain



Piriform Cortex

- Largest real estate in the olfactory system
- A 3-layer paleocortical brain area with no columnar organization.
- Sends neurons to:
 - Orbital Frontal Cortex (decisions and emotions)
 - **Medial Amygdala and Olfactory Cortical Amygdala**

Limbic System (Unconscious)

- There isn't a universally agreed list of structures that compose the limbic system.
- The typical brain regions are the **cingulate gyrus** (emotion, learning and memory), **amygdala** (emotion), **septal area** (pleasure and reproduction), **hippocampus** (memory), and **hypothalamus** (temperature regulation, thirst, hunger, sleep, mood, sex).
- **The nucleus accumbens** ("pleasure center", reward structure, recall) can be included.

Amygdala (emotions)

- The amygdala plays a key part in what has been called the "general-purpose defense response control network" and reacts in response to pleasant and unpleasant sensations, including **smells**.
- The amygdala's evolutionary origins has direct connections to one of the oldest sensory areas, i.e., **olfaction**.
- The **amygdala** may directly encode **emotional memory** to some extent, working with the **hippocampus**.

Hippocampus (memory)

- The hippocampus deals with memory and spatial navigation.
- The hippocampus is a small region of the brain that forms part of the limbic system.
- It is primarily associated with formation of long-term memories and spatial navigation.
- The hippocampus is located in the medial temporal lobe of the brain, underneath the cortical surface.

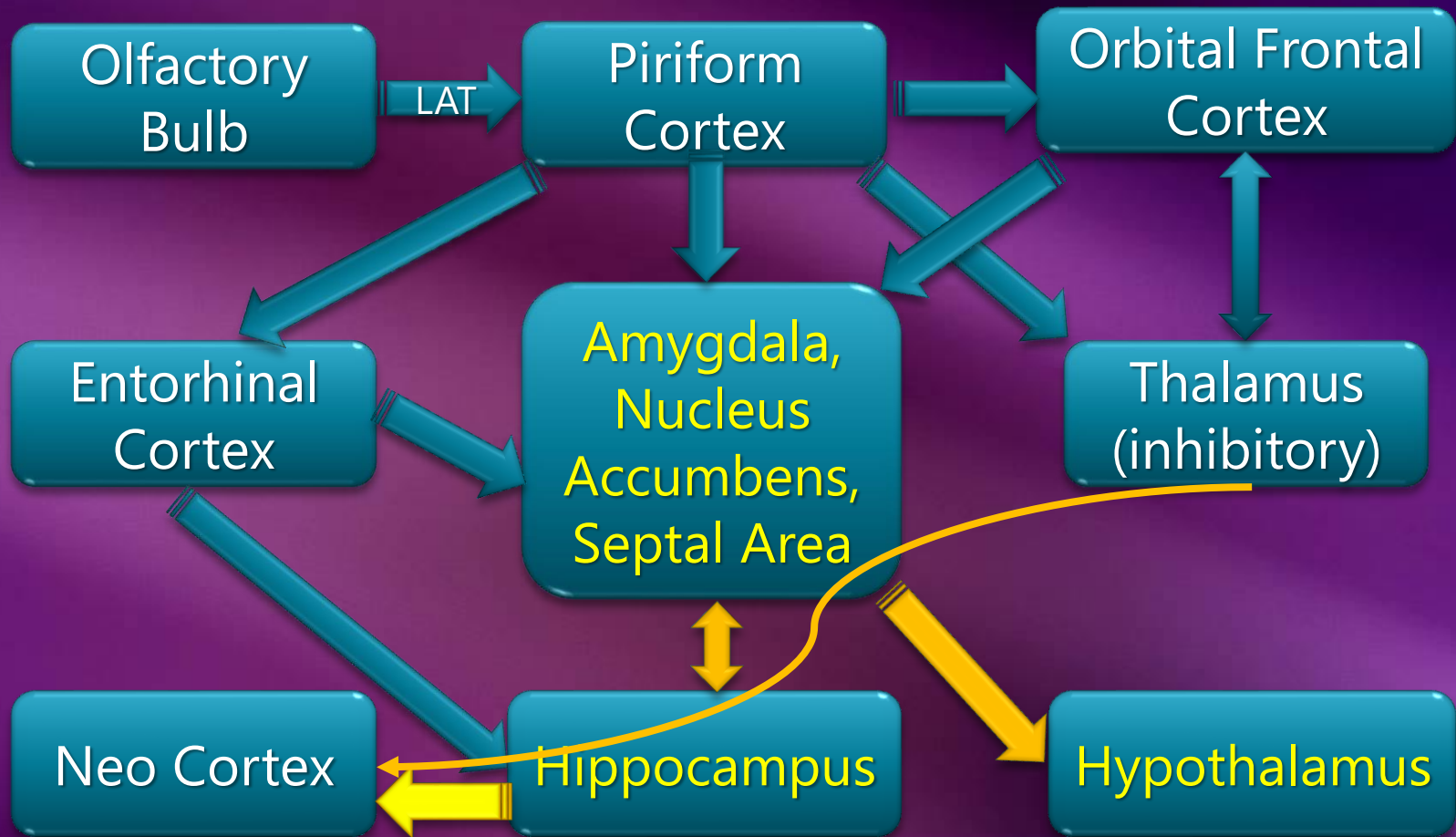
Entorhinal Cortex

- The entorhinal cortex (ento = interior, rhino = nose, entorhinal = interior to the rhinal sulcus) is an area of the brain located in the medial temporal lobe.
- The ability to find one's way depends on neural algorithms that integrate information about place, distance and direction, i.e., the Entorhinal Cortex.
- The Entorhinal Cortex is the main interface between the Hippocampus (memory) and Neocortex (consciousness).

Olfaction and Emotion

Summary

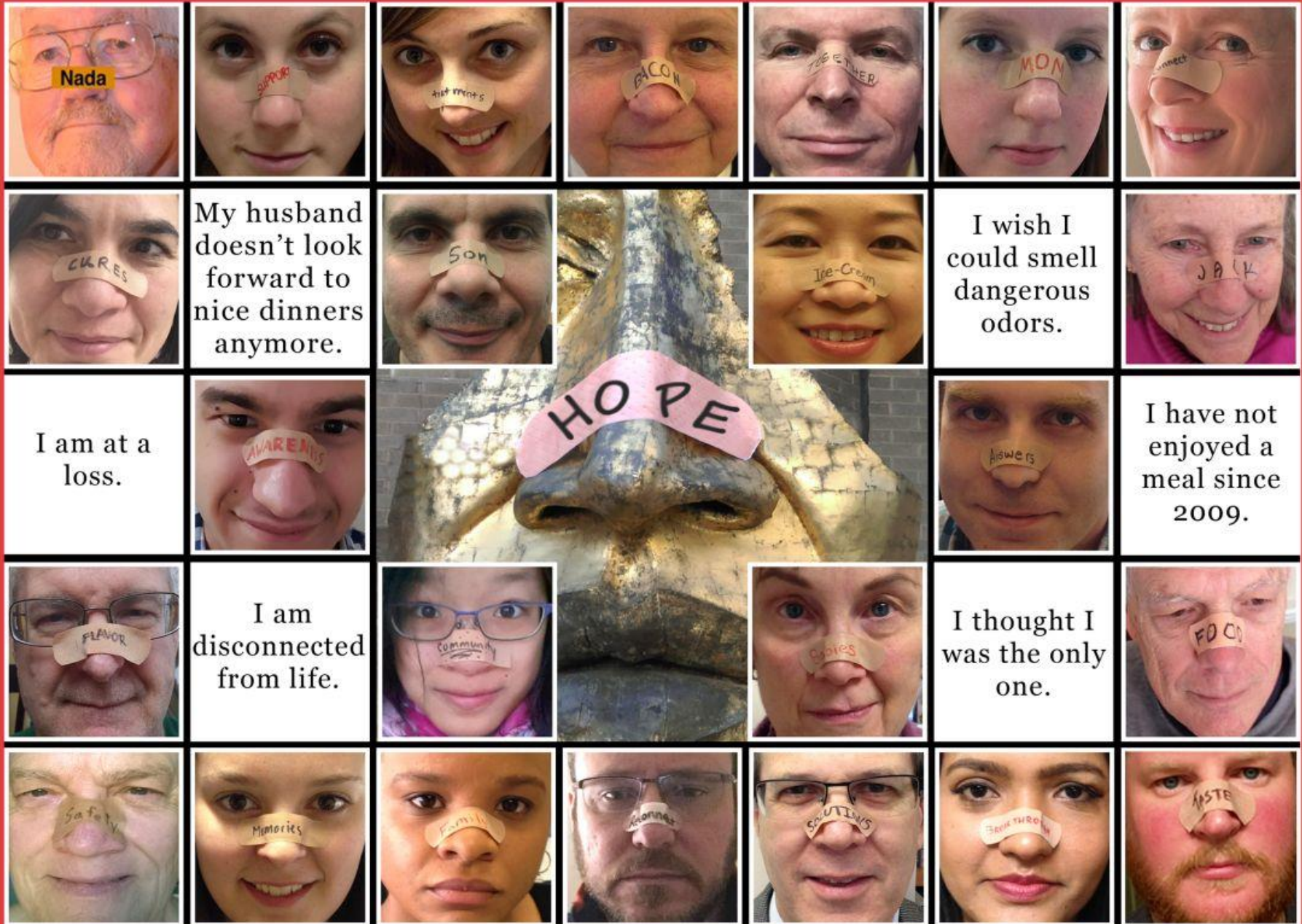
Olfactory/Limbic System



Life Without Smell

Anosmia – complete loss of smell

(Ageusia – complete loss of primary taste sensations)



My husband doesn't look forward to nice dinners anymore.

I wish I could smell dangerous odors.

I am at a loss.

I have not enjoyed a meal since 2009.

I am disconnected from life.

I thought I was the only one.

Faces of Anosmia



Anosmia is considered an invisible disability

72%	are scared of being exposed to danger	47%	report feeling isolated
72%	change in perception of their own body odor	46%	report feeling more vulnerable
66%	Feeling more anxious	38%	affected their romantic relationship
64%	enjoyment of food has decreased	36%	lose motivation to eat
50%	makes them feel angry	32%	decreased enjoyment of intimacy

Anosmia and Emotions

- Frankly, the loss of my sense of smell and the effect it has had on my perception of things has dampened the colors of the world for me.
- Life is not the same. Anything I eat is the same as eating or chewing cardboard. My life is now full of depression.
- Losing my sense of smell was a huge blow. Smells *evoke memories* and enrich life. Life seems very empty, like I was living in a box and looking out at the world.

Common Causes of Anosmia

- Nasal Polyps, Medication, Head Trauma, Cocaine, Radiation Treatment, Cancer, etc.
- Nasal Sinus Disease (15%-29%)
- Prior Upper Respiratory Infections (14%-26%)
- Inborn or Acquired in Early Infancy (3%-4%)
- 80+ years of age (60%). Sense of smell begins to decline at about 60 years of age
- Kallmman's Syndrome (hypo-gonadotropic hypo-gonadism)

“Specific” Anosmia (1% - 3% of Population)

- Specific Anosmia can be considered an “olfactory blind spot”. See <http://chemconnections.org/Smells/>
 - Androstenone: vanilla, Urine or Musky/Woody
 - Isovaleric acid (3-Methylbutanoic acid): sweat
 - l-pyrroline: white bread or jasmine rice
 - Trimethylamine: strong "fishy" odor in low concentrations and an ammonia-like odor at higher concentrations.
 - Isobutyraldehyde: sharp, pungent **odor**

My Career

- Measuring emotional reactions to fragrance, aroma and odorants
- Reverse engineer fragrance emotional profiles to objective descriptors of fragrance.
 - By culture
 - Across cultures
- Guide Perfumers and Flavorists in modifications
- Test newly modified samples

The Creative Team

Perfumers and Evaluators

Creative Perfumer (artistic)

- Must have natural sensory abilities:
 - No Specific Anosmia's
 - Low Odor Thresholds
 - Ease of Recognition (memory)
 - Ease of Identification (the parts of a fragrance)
- Must be Creative:
 - At least 3 years of formal training
 - At least 5-10 years of experience
 - Artistic (mixology and abstract thinking)
 - Science (chemistry; ingredients)
 - **Must understand the emotional connections**

Evaluator (more cognitive)

- Must have natural sensory abilities
 - No Specific Anosmia's
 - Low Odor Thresholds
 - Ease of Recognition (memory)
 - Ease of Identification (the parts of a fragrance)
 - Slow sensory adaptation
- Must Be Objective:
 - At least 1 year of training
 - About 3 years of experience
 - **Must Attach Nose to Brain (objective translator)**
 - Choose a specialty (CPG; Fine Fragrance)

Perfumer



Scent Strips



Perfumer's Organ



Evaluation Training



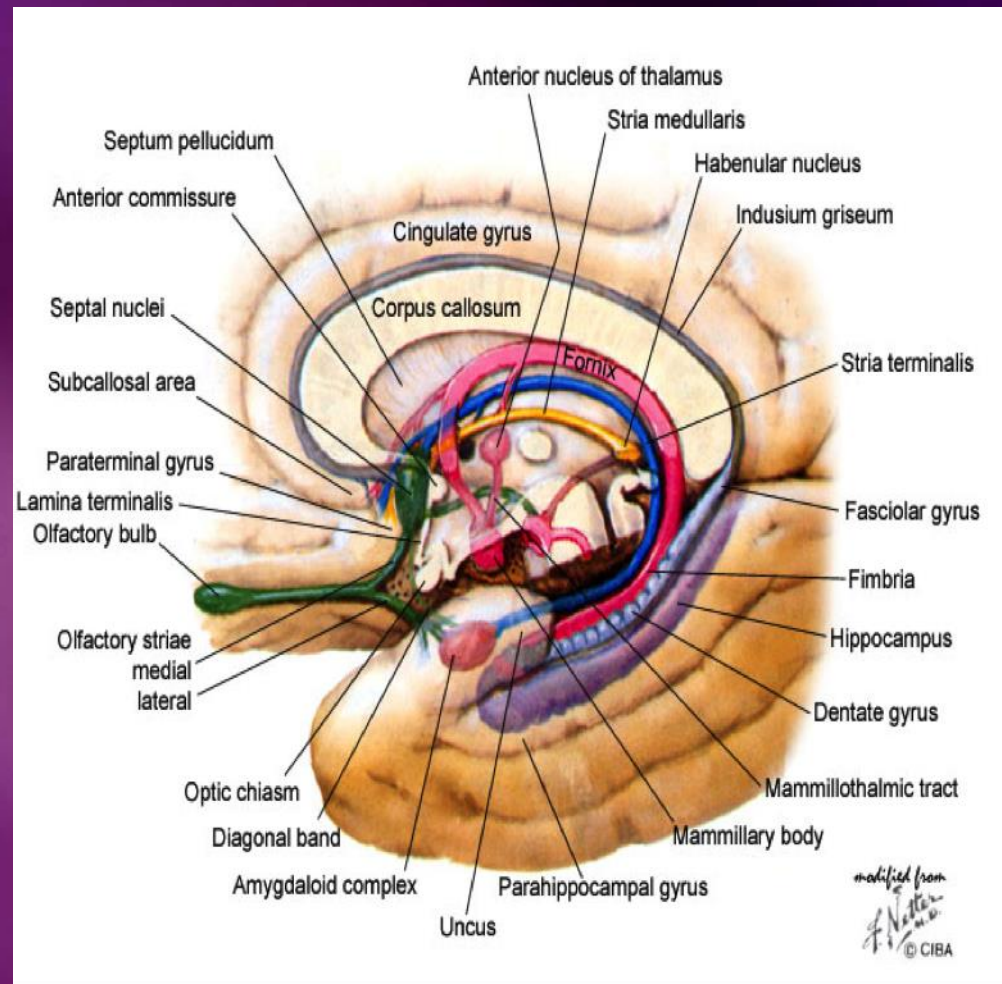
Thank You

Extra slides follow

Some Internet Links

- The Fragrance Foundation:
 - <http://fragrance.org/>
- The Fashion Institute of Technology:
 - <http://www.fitnyc.edu/>
- International Food Technologists:
 - <https://www.ift.org/>
- Journal of Chemical Sciences:
 - <http://www.springer.com/chemistry/journal/12039>
- Journal of Sensory Studies:
 - [http://onlinelibrary.wiley.com/journal/10.1111/\(ISSN\)1745-459X/issues](http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1745-459X/issues)
- Monell Chemical Senses:
 - <http://www.monell.org/>

Limbic Plus



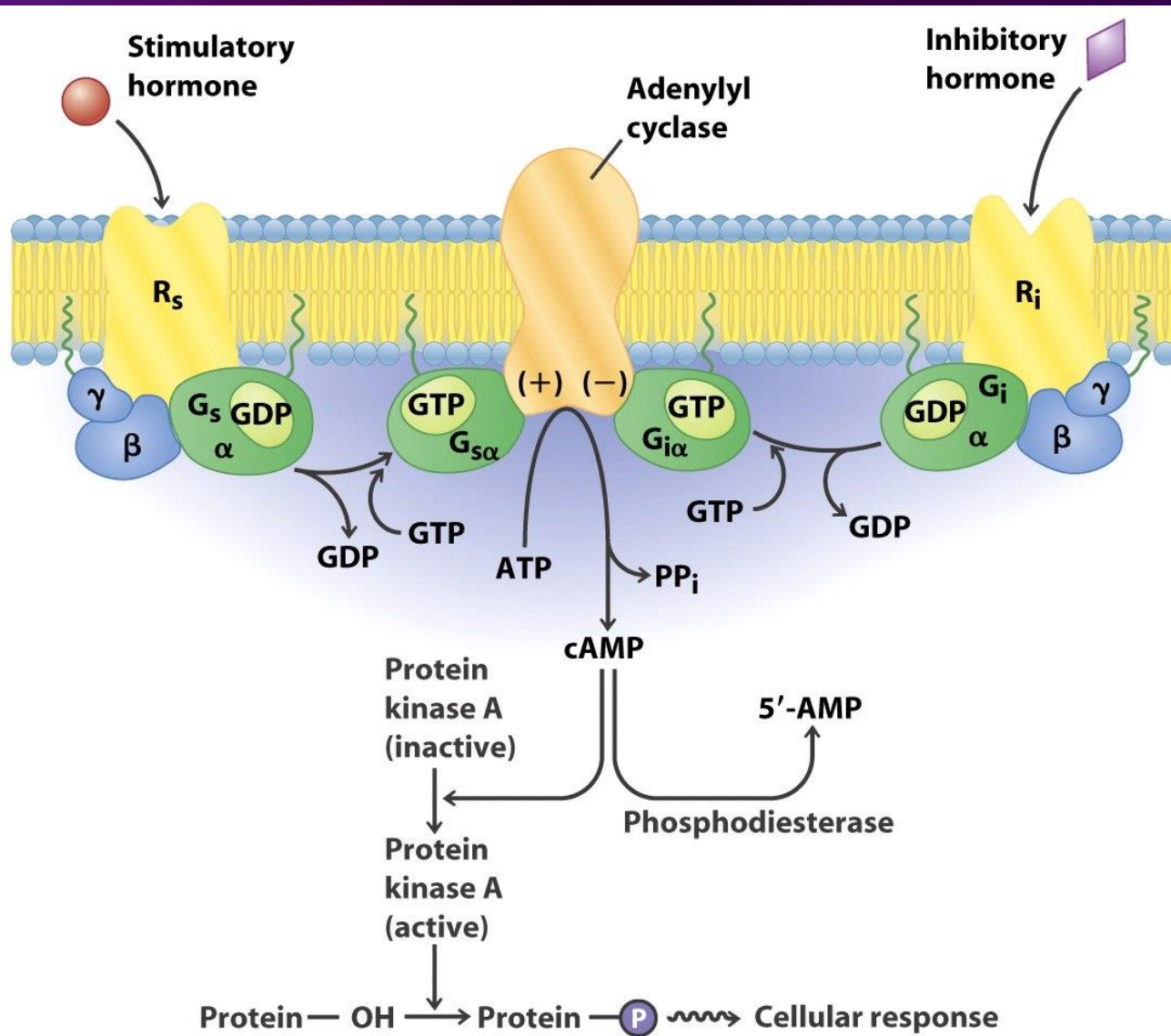


Figure 9-43 Principles of Biochemistry, 4/e
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