Physiology - Topic 11 - Special Senses

Physiological Principles of the Special Senses

From a Stimulus to a Perception

- The **special senses** include smell, taste, hearing, equilibrium and vision.
    - Each sense uses specialised receptors to convert a particular form of energy into an electrical signal.
    - This conversion is called **sensory transduction**.
    - A receptor potential changes transmitter release or triggers action potentials in the sensory pathway.
- The brain identifies the type and location of a stimulus from the pathway that is activated.
    - Stimulus strength is represented by firing patterns, firing **frequency** and the number of receptors recruited.
- **Adaptation** reduces the response to a sustained stimulus.
    - Its speed and completeness differ between receptor systems and also depend on central processing.

Physiology of Smell

Olfactory Receptors and Transduction

Receptor Organisation

A. Receptor Neurons

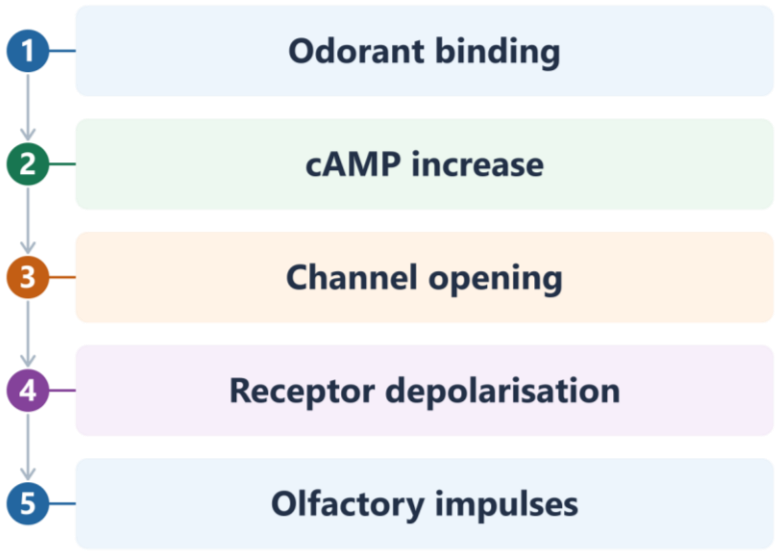
- **Olfactory receptor neurons** are bipolar neurons in specialised epithelium near the roof of the nasal cavity.
- Their cilia project into mucus and contain receptors for odorant molecules.
- An **odorant** must reach the olfactory epithelium and dissolve in its mucus before it can activate a receptor.
- Sniffing improves delivery of odorants to this region.

B. Supporting and Basal Cells

- **Supporting cells** help maintain the local environment.
- Basal cells can replace olfactory receptor neurons, although recovery after injury is not always complete.

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Electrical Response



Receptor Activation

- Many odorant receptors are **G-protein-coupled receptors**.
- Receptor activation stimulates an olfactory G protein and adenylyl cyclase, increasing intracellular cAMP.

Receptor Potential

- **cAMP** opens cyclic-nucleotide-gated channels.
- Sodium and calcium entry depolarises the receptor neuron, and calcium-activated chloride efflux amplifies the response.

Afferent Impulses

- If the depolarisation is sufficient, action potentials travel along the receptor neuron's axon.
- These axons pass through the cribriform plate and synapse in the olfactory bulb.

Olfactory Pathway and Coding

Central Connections

Olfactory Bulb

- Axons expressing the same receptor type converge on selected **glomeruli** in the olfactory bulb.
- Mitral and tufted cells carry output towards primary olfactory regions.

Cortical and Limbic Projections

- Olfactory projections reach the **piriform cortex**, amygdala and related areas.
- Their links with limbic and hypothalamic systems help explain the emotional and autonomic effects of odours.
- Primary olfactory information reaches cortex without the obligatory first thalamic relay used by most other senses.

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- Further processing for conscious identification includes orbitofrontal connections through the thalamus.

Odour Coding and Adaptation

Combinatorial Odour Coding

- A smell is represented by a pattern of activity across several receptor types rather than by a separate receptor for every possible odour.
- Different concentrations can change the pattern and the perceived quality.

Adaptation

- **Adaptation** has both receptor and central components.
- A familiar background odour may become less noticeable even though it is still present.

Applied Physiology and Testing

Disorders and Functional Effects

- **Anosmia** means loss of smell, **hyposmia** means reduced smell, and **parosmia** means distorted smell.
  - A perceived odour without an external source is called phantosmia.
  - Nasal obstruction may prevent odorants from reaching receptors.
  - Infection, head injury, receptor damage and disease affecting central pathways can also impair smell.
- Smell contributes strongly to **flavour**, so loss of smell is often reported as a loss of taste.
  - It also reduces awareness of smoke, spoiled food and some environmental hazards.

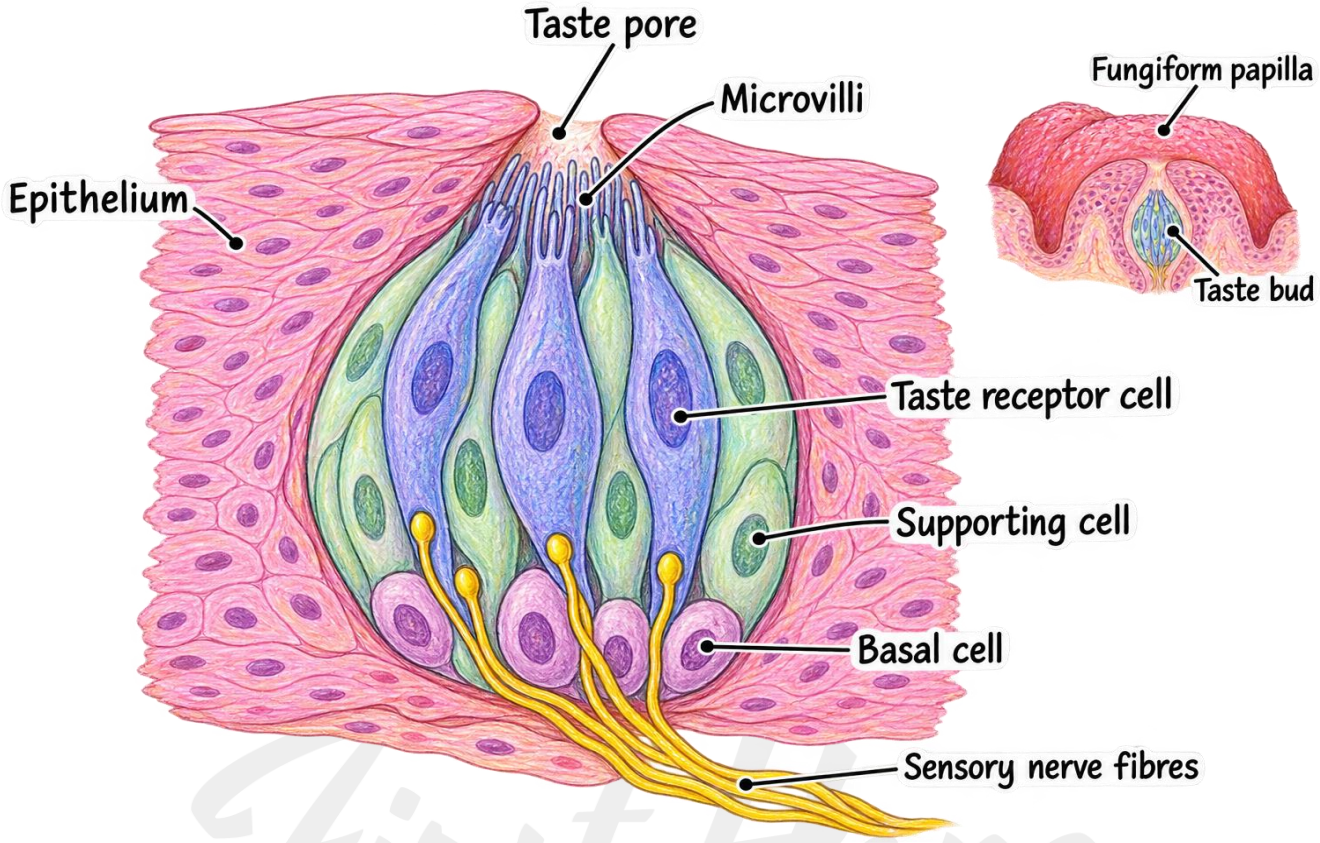
Clinical Testing of Smell

- Test each nostril separately with familiar, non-irritating odours while the eyes are closed.
  - Check nasal patency first and avoid substances such as ammonia that strongly stimulate trigeminal endings.
  - An inability to name an odour may reflect unfamiliarity or a language problem.
  - Compare detection, recognition and the clinical setting before interpreting the result.

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Physiology of Taste

Taste Buds and Primary Qualities



A taste bud and its papillary context, showing the taste pore, receptor cells and sensory nerve fibres. Taste qualities are not confined to separate tongue zones

Taste-Bud Distribution and Structure

Papillae Containing Taste Buds

- Taste receptor cells lie within **taste buds**, which occur mainly in fungiform, foliate and circumvallate papillae and at a few additional oral and pharyngeal sites.
- Filiform papillae mainly serve mechanical functions and do not contain ordinary **taste buds**.

Taste Receptor Cells

- Dissolved substances reach receptor-cell microvilli through the **taste pore**.
- Taste cells are specialised epithelial cells that communicate with sensory nerve endings and are regularly renewed.

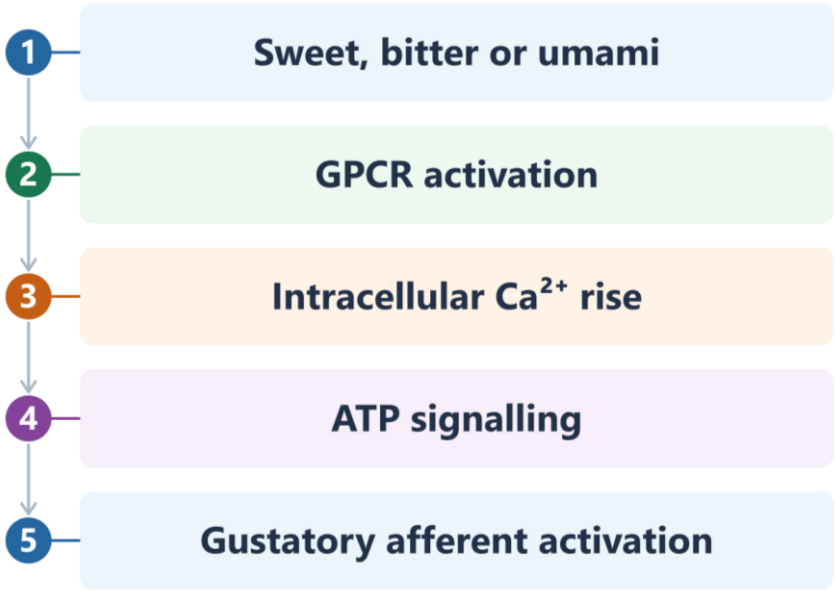
Primary Taste Qualities

- The five widely recognised primary taste qualities are **sweet, salty, sour, bitter and umami**.
  - Umami is associated with amino acids such as glutamate.
  - Different tongue regions can detect all these qualities, although sensitivity differs.
  - A rigid tongue map with one exclusive taste at each site is incorrect.

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Taste Transduction

1. Sweet, Bitter and Umami



Receptor-Mediated Signalling

- These taste qualities use **G-protein-coupled receptors**.
- Intracellular signalling increases calcium and promotes release of a transmitter signal, commonly ATP, to afferent nerve endings.

Bitter Taste and Protective Responses

- **Bitter** sensitivity helps detect many potentially harmful substances, but bitterness does not prove that a food is poisonous.
- Taste interpretation also depends on experience and context.

2. Salty and Sour

A. Salty Taste

- **Salty** stimuli depend on ionic mechanisms, including sodium entry through selected channels.
- Human salt taste involves more than one pathway, so it should not be reduced to a single universal channel mechanism.

B. Sour Taste

- **Sour** taste detects acidity.
- Proton movement through channels such as OTOP1 and related intracellular effects depolarise sour-sensitive cells.

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