Plant responses, hormones and the brain

Phytochrome, auxin and gibberellins, the amylase practical, hormonal control, the regions of the human brain, brain imaging, and brain chemicals in ill health.

Coordination in plants

Plants have no nervous system, so coordination is by **plant growth factors (hormones)**, which are made in one part and act on another, and by **light receptors**. Responses are generally **slower** than in animals.

Phytochrome

Phytochrome is a **pigment** protein that detects **red and far-red light** and exists in two forms:

- **Pr** absorbs **red light** (660 nm) and is converted to **Pfr**.
- **Pfr** absorbs **far-red light** (730 nm), and is converted back to Pr. (It also reverts slowly in the dark.)

Pfr is the **active** form. It moves into the **nucleus** and **binds to transcription factors**, so it affects **gene expression**, controlling:

- **Germination** of seeds (light-sensitive seeds germinate in red light, since Pfr promotes it, and are inhibited by far-red),
- **Flowering** (long-day and short-day plants), and
- **Shade avoidance** (stem elongation), as shaded light is rich in far-red.

Auxin (IAA)

Auxin (indoleacetic acid) is made in the **shoot tip** and moves down the stem.

- **Phototropism**: in a shoot lit from one side, auxin moves to the **shaded side**. It stimulates cells there to **elongate** by increasing the **loosening of the cell wall**. The cells on the shaded side grow **more**, so the shoot **bends towards the light**.
- **Mechanism**: auxin binds to a receptor and **activates the transcription of genes** (e.g. for proteins that pump H^+ into the wall and lower its pH). The **acid** activates enzymes (expansins) that **break the hydrogen bonds** between cellulose fibres, so the walls become more flexible, and **water enters by osmosis**, so the cell elongates.
- In **roots**, high auxin **inhibits** growth, so roots bend **away from light** (negative phototropism) and grow **downwards** (positive gravitropism).
- Also: **apical dominance** (auxin from the tip inhibits lateral buds).

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Gibberellins

Gibberellins are made in the **embryo** of a germinating seed and **stimulate germination** and **stem elongation**.

- When a seed absorbs water, the embryo releases **gibberellin**, which moves to the **aleurone layer** and **switches on the gene for amylase** (by acting on transcription factors).
- **Amylase** hydrolyses the **starch** in the endosperm to **maltose** and then glucose, which is used for **respiration** and growth.
- Gibberellins also make stems elongate: dwarf varieties are often short because they make little gibberellin.

Core Practical 18: amylase in germinating grain

1. Cut cereal grains (e.g. barley) in half and place the **embryo-less** halves on **starch agar**, with and without **gibberellin** (and with a control).
2. After incubation, flood the plate with **iodine solution**: the starch gives a **blue-black** colour, and where amylase has **digested** the starch, there is a **clear zone** around the grain.
3. Measure the **diameter of the clear zone**.

Grains with embryos, or those with added gibberellin, have **larger** clear zones, which shows that gibberellin from the embryo stimulates amylase production.

Coordination in animals

Both **nervous** and **hormonal** control coordinate responses. **Hormones** are carried in the **blood** to target cells with specific receptors, and have slower, longer-lasting and widespread effects.

The human brain

Region	Location and function
Cerebral hemispheres	Two halves of the **cerebrum**, which control **conscious thought**, memory, language, **voluntary movement** and sensory processing
Hypothalamus	Regulates **temperature**, **water balance**, hunger and thirst, and controls the **pituitary gland**
Pituitary gland	Releases hormones (e.g. **ADH**, growth hormone), and controls other glands
Cerebellum	Coordinates **movement**, **balance** and posture
Medulla oblongata	Controls **autonomic** functions: **heart rate**, **breathing** and blood pressure

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Brain imaging

Technique	How it works and uses
CT (computed tomography)	X-rays from many angles produce a **3D image** of structure. Quick; detects tumours, haemorrhage and bone, but uses ionising radiation
MRI (magnetic resonance imaging)	Strong magnetic fields and radio waves detect **hydrogen nuclei**, giving **detailed images of soft tissue** (structure). Safe (no ionising radiation) but expensive
fMRI (functional MRI)	Detects **changes in blood flow and oxygen use**, showing which parts of the brain are **active** during a task
PET (positron emission tomography)	A **radioactive tracer** (e.g. glucose labelled with a positron emitter) is injected; **gamma rays** from active areas show **metabolic activity**. Used in diagnosing dementia and cancer. Uses radiation

Brain chemicals and ill health

Imbalances in **neurotransmitters** can contribute to disease.

- **Dopamine** deficiency in **Parkinson's disease**: the death of dopamine-producing neurones leads to tremor, rigidity and slow movement. **L-DOPA** is converted to dopamine, which relieves the symptoms.
- **Serotonin** imbalance in **depression**: low serotonin activity is linked to low mood. **Selective serotonin reuptake inhibitors (SSRIs)** block re-uptake and increase the amount of serotonin in the synapse.

The understanding of these chemicals has led to the **development of new drugs**, although these need **rigorous testing** for effects and side effects.

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