ADRENAL GLANDS

The adrenal glands are two small hormone-producing organs located above the kidneys. They belong to the endocrine system, which uses hormones (chemical messengers carried through the bloodstream) to coordinate body functions. Each gland has an outer cortex and an inner medulla. These regions produce different hormones but work together to help regulate energy availability, blood pressure, fluid balance, and responses to physical and emotional demands.

THE CORTEX: CORTISOL & ALDOSTERONE

The cortex produces cortisol, a hormone that helps regulate metabolism: how the body processes and uses carbohydrates, fats, and proteins. Cortisol helps maintain blood glucose between meals, influences inflammation and immune activity, and supports the ability of blood vessels to maintain pressure. Although commonly called the "stress hormone," cortisol is essential during ordinary daily life, too. Its release increases during demands such as illness, injury, and psychological stress. The cortex also produces aldosterone, which signals the kidneys to retain sodium and release potassium into urine. Water follows retained sodium, helping maintain circulating blood volume and blood pressure. Aldosterone responds mainly to blood potassium levels and the renin–angiotensin system, a communication pathway activated when the kidneys detect reduced blood flow. The cortex also makes adrenal androgens, including DHEA, which can be converted to other sex hormones.

THE MEDULLA: ADRENALINE & NORADRENALINE

The medulla produces adrenaline, also called epinephrine, and noradrenaline, also called norepinephrine. These hormones participate in the rapid "fight-or-flight" response. Signals from the sympathetic nervous system (the branch involved in immediate readiness) stimulate their release. They increase heart activity, mobilize stored fuel, and alter blood flow so the body can respond quickly. Noradrenaline also acts as a messenger between nerve cells; most circulating noradrenaline comes from nerve endings rather than the adrenal glands.

BRAIN COMMUNICATION & DAILY RHYTHM

Cortisol production follows the hypothalamic–pituitary–adrenal axis, or HPA axis. The hypothalamus in the brain releases CRH, which prompts the pituitary gland to release ACTH. ACTH then signals the adrenal cortex to produce cortisol. Cortisol feeds back to the brain and pituitary, reducing further stimulation in a process called negative feedback. Cortisol also follows a circadian rhythm, the body's approximately 24-hour timing cycle. Levels usually rise before waking, increase shortly after awakening, and decline toward nighttime. Sleep timing, light exposure, illness, and stress can influence this pattern. A temporary increase is part of normal adaptation and does not by itself establish a disorder.

TERMS & SIGNIFICANCE

Adrenal insufficiency means inadequate production of cortisol; primary adrenal insufficiency may also involve low aldosterone. Cushing syndrome involves prolonged excessive cortisol exposure. These differ from "adrenal fatigue," a proposed explanation for exhaustion that is not an established medical diagnosis. Hormone measurements depend on collection timing, medications, illness, and testing methods, so a single result does not describe the whole system. Understanding adrenal function shows how closely the brain, kidneys, circulation, immune system, and metabolism communicate.

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