# Hormone of Adrenal medulla , Adrenaline and Nor-adrenaline

## Adrenaline

**Adrenaline, also known as epinephrine**, is a hormone and medication. Adrenaline is normally produced by both the adrenal glands and a small number of neurons in the medulla oblongata, where it acts as a neurotransmitter involved in regulating visceral functions (e.g., respiration). It plays an important role in the fight-or-flight response by increasing blood flow to muscles, output of the heart, pupil dilation response and blood sugar level. It does this by binding to alpha and beta receptors. It is found in many animals and some single-celled organisms. Polish physiologist Napoleon Cybulski first isolated epinephrine in 1895.

## Physiological Effects:

**Exercise**: One physiological stimulus to adrenaline secretion is exercise. This was first demonstrated using the denervated pupil of a cat as an assay, later confirmed using a biological assay on urine samples. Biochemical methods for measuring catecholamines in plasma were published from 1950 onwards. Although much valuable work has been published using fluorimetric assays to measure total catecholamine concentrations, the method is too non-specific and insensitive to accurately determine the very small quantities of adrenaline in plasma. The development of extraction methods and enzyme-isotope derivate radio-enzymatic assays (REA) transformed the analysis down to a sensitivity of 1 pg for adrenaline. Early REA plasma assays indicated that adrenaline and total catecholamines rise late in exercise, mostly when anaerobic metabolism commences.

During exercise the adrenaline blood concentration rises partially from increased secretion from the adrenal medulla and partly from decreased metabolism because of reduced hepatic blood flow. Infusion of adrenaline to reproduce exercise circulating concentrations of adrenaline in subjects at rest has little haemodynamic effect, other than a small $\beta_2$-mediated fall in diastolic blood pressure. Infusion of adrenaline well within the physiological range suppresses human airway hyper-reactivity sufficiently to antagonize the constrictor effects of inhaled histamine.

A link between what we now know as the sympathetic system and the lung was shown in 1887 when Grossman showed that stimulation of cardiac accelerator nerves reversed muscarine-induced airway constriction. In experiments in the dog, where the sympathetic chain was cut at the level of the diaphragm, Jackson showed that there was no direct sympathetic innervation to the lung, but that bronchoconstriction was reversed by release of adrenaline from the adrenal medulla. An increased incidence of asthma has not been reported for adrenalectomized patients; those with a predisposition to asthma will have some protection from airway hyper-reactivity from their corticosteroid replacement therapy. Exercise induces progressive airway dilation in normal subjects that correlates with work load and is not prevented by beta blockade. The progressive dilation of the airway with increasing exercise is mediated by a progressive reduction in resting vagal tone. Beta blockade with propranolol causes a rebound in airway resistance after exercise in normal subjects over the same time course as the

bronchoconstriction seen with exercise induced asthma. The reduction in airway resistance during exercise reduces the work of breathing.

**Emotional response:** Every emotional response has a behavioral component, an autonomic component, and a hormonal component. The hormonal component includes the release of adrenaline, an adrenomedullary response that occurs in response to stress and that is controlled by the sympathetic nervous system The major emotion studied in relation to adrenaline is fear. In an experiment, subjects who were injected with adrenaline expressed more negative and fewer positive facial expressions to fear films compared to a control group. These subjects also reported a more intense fear from the films and greater mean intensity of negative memories than control subjects. The findings from this study demonstrate that there are learned associations between negative feelings and levels of adrenaline. Overall, the greater amount of adrenaline is positively correlated with an arousal state of negative feelings. These findings can be an effect in part that adrenaline elicits physiological sympathetic responses including an increased heart rate and knee shaking, which can be attributed to the feeling of fear regardless of the actual level of fear elicited from the video. Although studies have found a definite relation between adrenaline and fear, other emotions have not had such results. In the same study, subjects did not express a greater amusement to an amusement film nor greater anger to an anger film. Similar findings were also supported in a study that involved rodent subjects that either were able or unable to produce adrenaline. Findings support the idea that adrenaline does have a role in facilitating the encoding of emotionally arousing events, contributing to higher levels of arousal due to fear.

**Memory:** It has been found that adrenergic hormones, such as adrenaline, can produce retrograde enhancement of long-term memory in humans. The release of adrenaline due to emotionally stressful events, which is endogenous adrenaline, can modulate memory consolidation of the events, ensuring memory strength that is proportional to memory importance. Post-learning adrenaline activity also interacts with the degree of arousal associated with the initial coding. There is evidence that suggests adrenaline does have a role in long-term stress adaptation and emotional memory encoding specifically. Adrenaline may also play a role in elevating arousal and fear memory under particular pathological conditions including post-traumatic stress disorder. Overall, "Extensive evidence indicates that epinephrine (EPI) modulates memory consolidation for emotionally arousing tasks in animals and human subjects." Studies have also found that recognition memory involving adrenaline depends on a mechanism that depends on β adrenoceptors. Adrenaline does not readily cross the blood–brain barrier, so its effects on memory consolidation are at least partly initiated by β adrenoceptors in the periphery. Studies have found that sotalol, a Beta Adrenergic Agonist that also does not readily enter the brain, blocks the enhancing effects of peripherally administered adrenaline on memory. These findings suggest that β adrenoceptors are necessary for adrenaline to have an effect on memory consolidation.

## Nor-adrenaline

Norepinephrine (NE), also called noradrenaline (NA) or noradrenalin, is an organic chemical in the catecholamine family that functions in the brain and body as

a hormone and neurotransmitter. The name "noradrenaline", derived from Latin roots meaning "at/alongside the kidneys", is more commonly used in the United Kingdom; in the United States, "norepinephrine", derived from Greek roots having that same meaning, is usually preferred. "Norepinephrine" is also the international nonproprietary name given to the drug. Regardless of which name is used for the substance itself, parts of the body that produce or are affected by it are referred to as noradrenergic.

**Physiological Effects:**

**Cellular effects:** Like many other biologically active substances, norepinephrine exerts its effects by binding to and activating receptors located on the surface of cells. Two broad families of norepinephrine receptors have been identified, known as alpha and beta adrenergic receptors. Alpha receptors are divided into subtypes $\alpha_1$ and $\alpha_2$; beta receptors into subtypes $\beta_1$, $\beta_2$, and $\beta_3$. All of these function as G protein-coupled receptors, meaning that they exert their effects via a complex second messenger system. Alpha-2 receptors usually have inhibitory effects, but many are located pre-synaptically (i.e., on the surface of the cells that release norepinephrine), so the net effect of alpha-2 activation is often a decrease in the amount of norepinephrine released. Alpha-1 receptors and all three types of beta receptors usually have excitatory effects.

**Storage, release, and reuptake:** Inside the brain norepinephrine functions as a neurotransmitter, and is controlled by a set of mechanisms common to all monoamine neurotransmitters. After synthesis, norepinephrine is transported from the cytosol into synaptic vesicles by the vesicular monoamine transporter (VMAT). Norepinephrine is stored in these vesicles until it is ejected into the synaptic cleft, typically after an action potential causes the vesicles to release their contents directly into the synaptic cleft through a process called exocytosis.

Once in the synapse, norepinephrine binds to and activates receptors. After an action potential, the norepinephrine molecules quickly become unbound from their receptors. They are then absorbed back into the presynaptic cell, via reuptake mediated primarily by the norepinephrine transporter (NET). Once back in the cytosol, norepinephrine can either be broken down by monoamine oxidase or repackaged into vesicles by VMAT, making it available for future release.

**Sympathetic nervous system:** The sympathetic effects of norepinephrine include:

- In the eyes, an increase in production of tears, making the eyes more moist, and pupil dilation through contraction of the iris dilator.
- In the heart, an increase in the amount of blood pumped.
- In brown adipose tissue, an increase in calories burned to generate body heat (thermogenesis).
- Multiple effects on the immune system. The sympathetic nervous system is the primary path of interaction between the immune system and the brain, and several components receive sympathetic inputs, including the thymus, spleen, and lymph nodes. However the effects are complex, with some immune processes activated while others are inhibited.
- In the arteries, constriction of blood vessels, causing an increase in blood pressure.
- In the kidneys, release of renin and retention of sodium in the bloodstream.

- In the liver, an increase in production of glucose, either by glycogenolysis after a meal or by gluconeogenesis when food has not recently been consumed. Glucose is the body's main energy source in most conditions.
- In the pancreas, increased release of glucagon, a hormone whose main effect is to increase the production of glucose by the liver.
- In skeletal muscles, an increase in glucose uptake.
- In adipose tissue (i.e., fat cells), an increase in lipolysis, that is, conversion of fat to substances that can be used directly as energy sources by muscles and other tissues.
- In the stomach and intestines, a reduction in digestive activity. This results from a generally inhibitory effect of norepinephrine on the enteric nervous system, causing decreases in gastrointestinal mobility, blood flow, and secretion of digestive substances