How Scientists Measure Stress

Laboratory tests are usually complemented by psychological questionnaires. With respect to the latter, capturing everyone's differing perception of stress is a challenge. This has led to multiple designs, which complicates comparisons across studies. The available laboratory tests are summarized in Fig.1.

Fig.1 Laboratory tests used to measure stress	
Catecholamines	In blood
Blood pressure	
Heart rate	
Cortisol	1) In blood, urine
	2) In saliva
	3) Hair cortisol concentration
Source: Biron, [(1)] Conceptasia, November 2021	

To help the understanding of where the above tests fit in, there follows an explanation of the body's physiological response to stress. There are two main neuroendocrine stress response systems:

1) Sympathetic Nervous System (often referred to as the "Fight or Flight system")
2) Hypothalamic-Pituitary Adrenal Axis (HPA Axis)

The two systems interact to enable the body to adapt to stress.

The Sympathetic Nervous System

The body's nervous system comprises:

1) The central nervous system (CNS) comprising the brain and spinal cord.

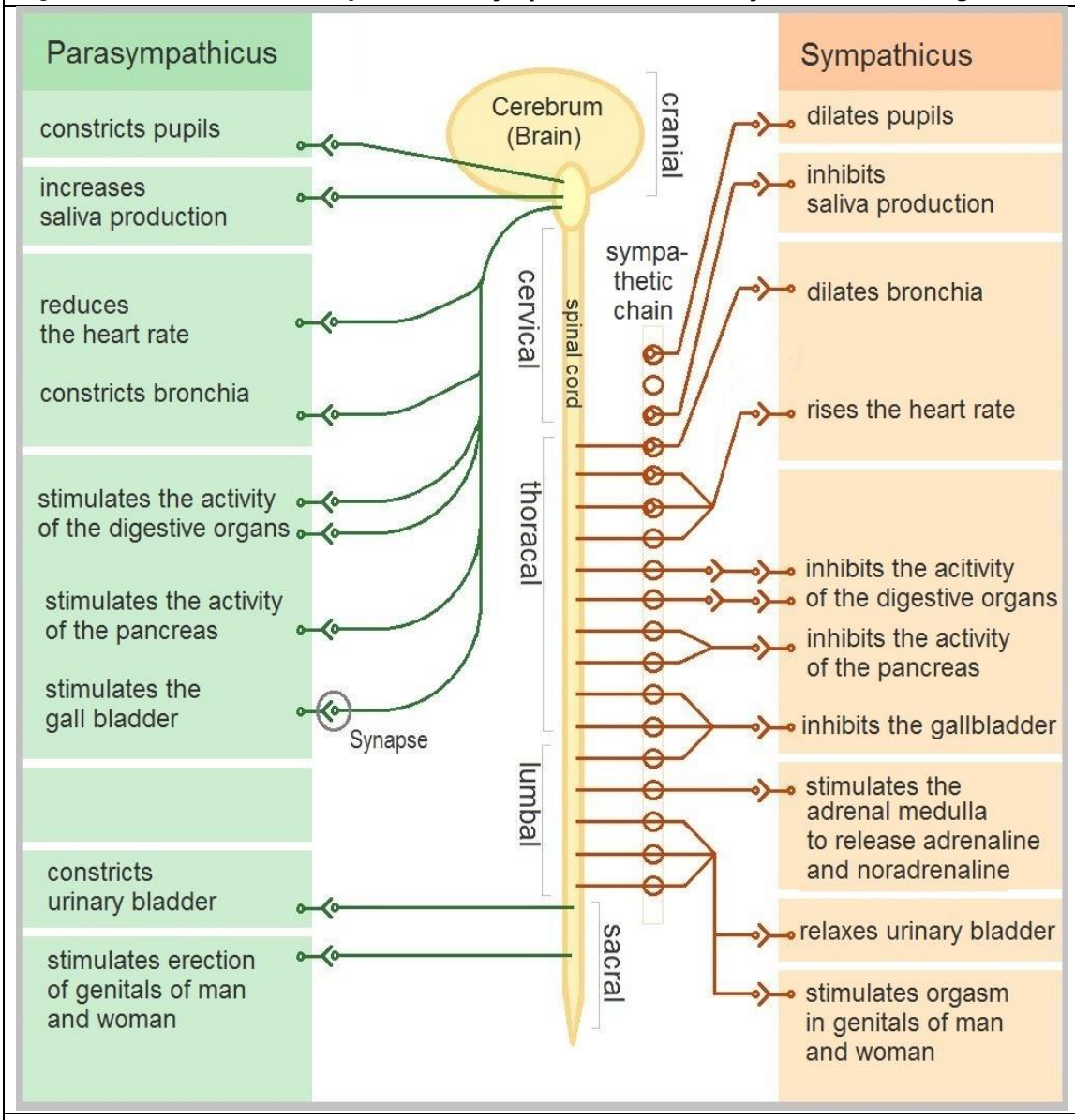
2) The peripheral nervous system (PNS), comprising the autonomic nervous system (ANS) and the somatic nervous system (SNS). The ANS controls unconscious functions, e.g., the heart rate, blood rate, digestion. The SNS controls voluntary body movement, e.g., motor, sensory.

3) The ANS, Fig.2, further subdivides into the **sympathetic nervous system** (for "fight or flight") and the parasympathetic nervous system (for "rest and digest"). Together, the sympathetic and parasympathetic system work to keep the body in optimum balance (homeostasis).

Dangerous or stressful situations trigger increased quantities of **catecholamines**, which are active in the transmission of nerve impulses between neurons. In turn, this leads to the reactions in the body noted below.

The “fight or flight” expression normally brings with it an image of our ancient ancestors facing a wild animal. However, the body undergoes similar changes in any situation associated with anxiety or stress. Even bad news, or just watching the news these days, can cause the heart rate and blood pressure to increase, respiration to increase, hyperventilation, and a decreased desire to eat, Fig.2.

Fig.2 The autonomic nervous system – the sympathetic nervous system is on the right



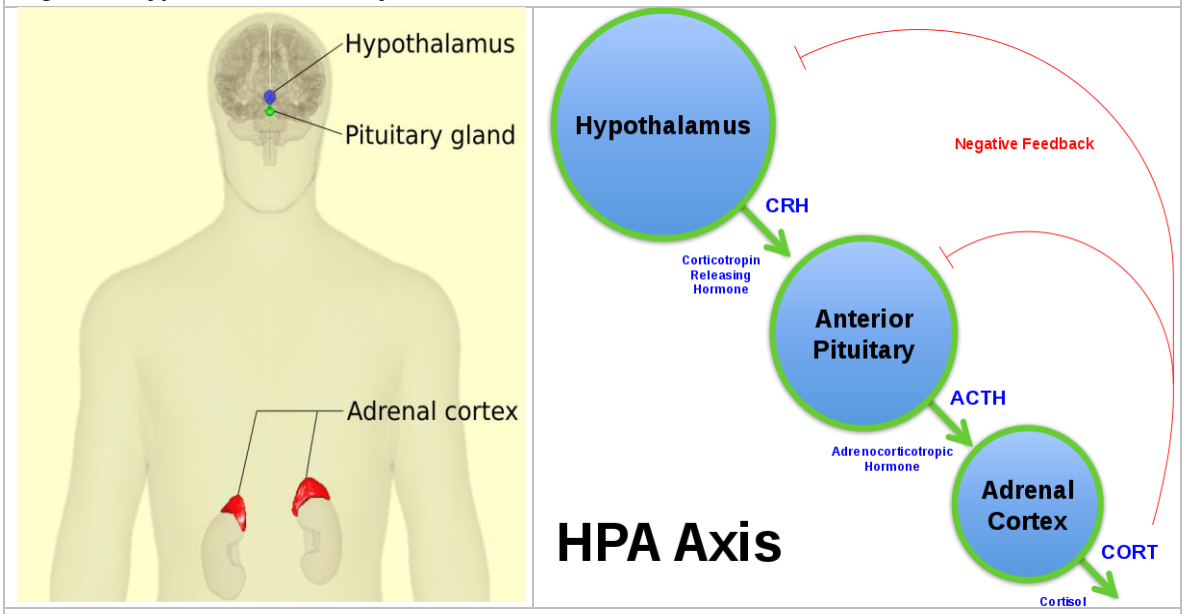
Source: Geo-Science International, Conceptasia, November 2021

Hypothalamic-Pituitary Adrenal Axis (HPA Axis)

Stress activates the HPA Axis, Fig.3, leading to an increase in the production of cortisol from the adrenals.

Increased production of cortisol during stress results in an increased availability of glucose to facilitate fight or flight. As well as directly increasing glucose availability, cortisol also suppresses the highly demanding metabolic processes of the immune system, resulting in the further availability of glucose. [2, 3]

Fig.3 The Hypothalamic-Pituitary Axis, HPA

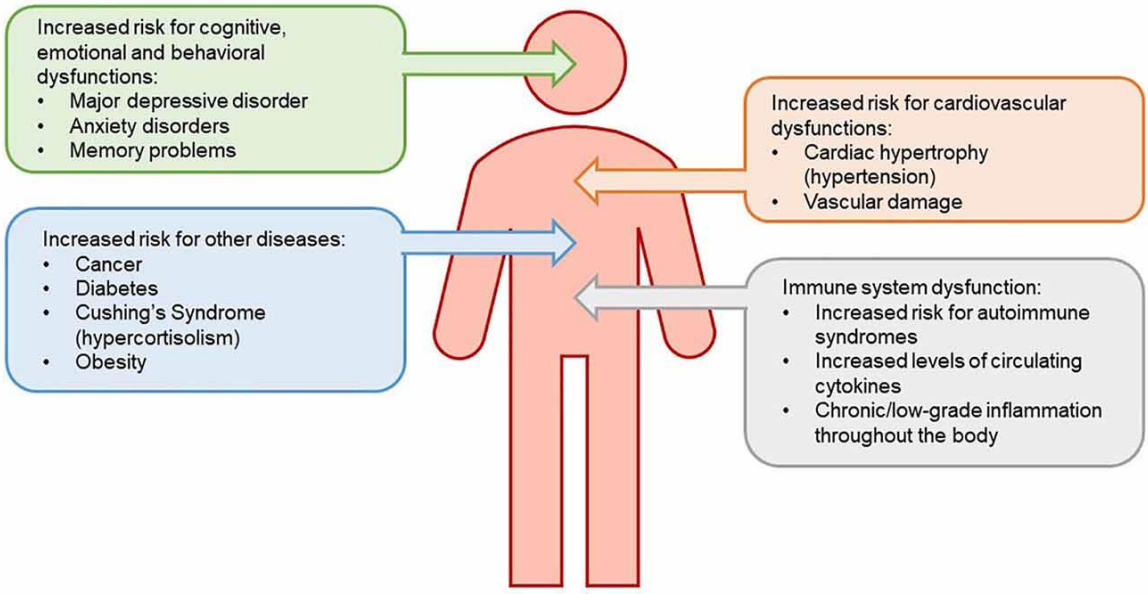


Additional source notes: Chart on the left - en:Anatomography (setting page of this image). Chart on the right: Derived from: HPA Axis Diagram (Brian M Sweis 2012).png

Source, Wikipedia, [2] Conceptasia, November 2021

Chronic stress leads to reduced sensitivity of the negative feedback system that governs the HPA Axis, Fig.3. HPA axis dysregulation results in downstream physiological consequences, increasing risk for immune system dysfunction, mood disorders, metabolic disease, and cardiovascular disease, Fig.4. [4]

Fig.4 The consequences of sustained high stress



Source: The Hypothalamic-Pituitary-Adrenal Axis: Development, Programming Actions of Hormones, and Maternal-Fetal Interactions, [4] Conceptasia, November 2021

Hair Cortisol Concentration

Hormone levels fluctuate for reasons other than stress, e.g., based on the time of day, illnesses, and related medicines, visiting a clinic, a fear of needles. This introduces major challenges for consistently measuring the stress level at a point in time. In addition, stress is a natural bodily response, and it is only sustained high stress levels which lead to health-related problems. Fortunately, there is now a laboratory test which measures stress levels over sustained periods, e.g., one month, three months: hair cortisol concentration. Hair grows in length by around one centimeter a month.

Hair cortisol sampling shows longer-term stress on the body as hair, overtime, will collect free cortisol in the blood. Free cortisol represents cortisol excreted by the body during stressful encounters that is not reabsorbed. [5]

The measurement of hair cortisol concentration (HCC) is an innovative process that has been shown to represent the biological effects of chronic stress on the human body. [6]

References

1) *Can a person's exposure to stress be measured,* Biron: *https://www.biron.com/en/education-center/your-questions/stress-exposition/*
2) Wikipedia – *the Hypothalamic–pituitary–adrenal axis*: https://en.wikipedia.org/wiki/Hypothalamic%E2%80%93pituitary%E2%80%93adrenal_axis
3) *The hypothalamus-pituitary-adrenal axis*, by Besedovsky, Hugo; Chrousos, George; Rey, and Adriana Del (2008), source [(2)].
4) *The Hypothalamic-Pituitary-Adrenal Axis: Development, Programming Actions of Hormones, and Maternal-Fetal Interactions*, by Julietta A. Sheng, Natalie J. Bales, Sage A. Myers, Anna I. Bautista, Mina Roueinfar, Taben M. Hale and Robert J. Handa, 2021
5) *Measuring suffering: assessing chronic stress through hair cortisol measurement in humanitarian settings*, by Tim Cunningham, 2018
6) *Analysis of cortisol in hair, state of the art and future directions*, by Stalder, T. & Kirschbaum, C., 2012, source [(5)]