

**In this article...**

- How the human body regulates its internal environment
- The central role of homoeostasis in keeping us alive
- The links between health, homoeostasis and vital signs

# Homoeostasis and vital signs: their role in health and its restoration



Nursing Times  
Self-assessment

## Key points

**1** The human body maintains itself in a stable state through homoeostasis, which is central to life

**2** Vital signs are an objective measure of homoeostasis

**3** In ill health, homoeostasis is challenged and vital signs go out of their normal range

**4** Clinical interventions are an attempt at restoring vital signs to their normal range and so restore homoeostasis

**5** Accurate measurement of vital signs is crucial in diagnosis, clinical decision-making and treatment

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**Abstract** For many of us, being healthy is being independent of clinical intervention and able to carry out our activities of daily living. Our bodies try to ensure this through a process called homoeostasis, which is often poorly understood. This article explores what homoeostasis is, why it is central to our lives and health, and how it links to the vital signs that inform clinical interventions. Understanding the theoretical underpinning of homoeostasis for health and the use of vital signs for diagnosis is essential for accurate clinical decision-making and the restoration of patients to health.

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The healthy human body does all the work it needs to maintain itself by what is known, in biology, as living processes, which include excretion of waste and inhalation of oxygen to release energy from sugar. It also uses the process of homoeostasis to maintain itself in balance – it makes just the right number of cells to replace worn-out ones, and just the correct amount of hormones to signal a reaction that needs to happen. This article explains homoeostasis, its central role in maintaining good health and how, in ill health, vital signs are key in helping to restore it.

### Activities of daily living

Most healthy adults live independent lives, carrying out a range of activities such as walking, feeding, excreting, washing and dressing. These activities, known as activities of daily living (ADL), reflect the body's underlying physiological processes and are used as a measure of health.

People in ill health are not always able to carry out all ADLs, or not to the same extent as those who are healthy.

Determining which ADLs they cannot do, or have difficulties doing, helps health professionals to assess their needs. The ADLs measure a person's dependency on help. They are used, for example, to assess patients before discharge to see whether they can resume independent living or need further support.

All the ADLs we carry out reflect the living processes that keep us alive. These, in turn, are carried out by our body systems. In health, this is done correctly and to the right level. How does this happen?

### Providing stability for cells

All life is cellular; that is, made of cells. Like all living organisms, humans must maintain our cells to keep us alive. Living organisms exist in two environments:

- The external environment, the planet on which we find ourselves, Earth;
- The internal environment, the one beneath our skin.

Our external environment varies constantly. We can measure the things that vary, or variables (such as the outside temperature, water levels, air pressure, oxygen

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levels and nitrogen levels), but can do little about them. Our internal environment is affected by these changes but needs to be stable for life to continue.

All cells in the body are made of chemicals, such as proteins, which are able to survive only in very particular conditions. For example, eggs consist mainly of a protein called albumin; when heated, the albumin becomes solid and we cannot 'unboil' it. Our bodies also contain albumin and are equally susceptible to temperature changes. Enzymes, which allow bodily reactions to happen, are made of proteins. Any deleterious changes to internal conditions would mean the enzymes would not function, and neither would we: our entire metabolism, the chemistry of our cells, would cease.

Both cells and proteins are extremely sensitive to changes in variables in the internal (as well as external) environment. Cells need to be kept, among other requirements, at certain temperatures, pH (a measure of hydrogen ion concentration revealing our acid-base balance), osmotic balance (the balance between water and solutes) and energy levels (sugar and oxygen). As the cells are in a vast community – the average adult human has tens of trillions of them – they also need to communicate to let each other know what is happening. All this is part of our internal environment, inside each of us.

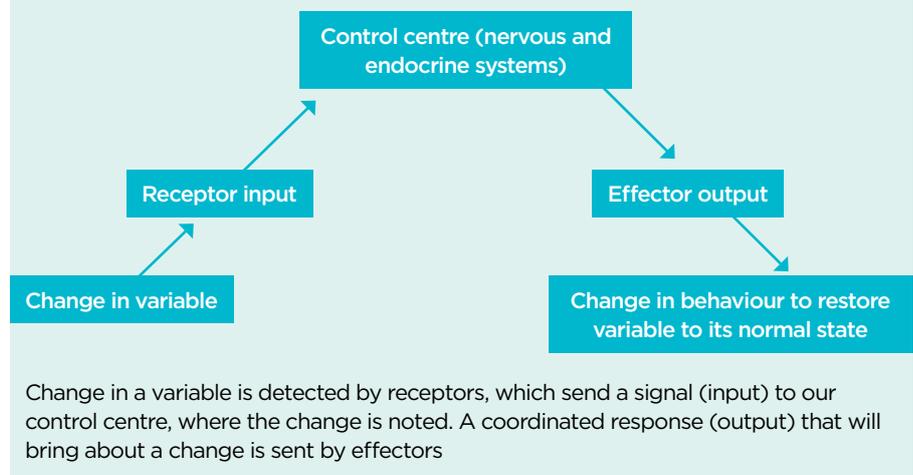
*“Homoeostasis is the cornerstone of health, and its restoration the cornerstone of clinical care”*

### Receptors and effectors

The body monitors itself automatically through body systems such as the nervous and endocrine systems. It has many detectors that receive information about changes in its internal environment – they are called receptors. Some receptors detect changes in chemicals (chemoreceptors); others in blood pressure (baroreceptors); temperature (thermoreceptors); or touch or heat so extreme that they cause pain (nociceptors). Each receptor is tuned to a particular frequency, called its modality, detecting one specific variable.

If a receptor receives information about a change of state in the variable it is designed to monitor, it sends signals to the brain for central coordination, so that all information is gathered in one place. A

Fig 1. **Detecting and responding to change**



response message is then sent out to elicit an appropriate behaviour or response. This response can be electrical (sent via the nervous system) or chemical (sent via the endocrine system) and it prompts a change, or effect, to return our internal conditions to an optimal state.

This is brought about by organs or cells known as 'effectors' because they effect a response (Fig 1).

### Fluctuating environments

Conditions in the external and internal environments vary constantly. The external environment may get hotter and colder. In the internal environment, water evaporates from the body; food alters the pH; cells die and need replacing in the correct number. The effect of these changes in the internal environment is monitored and compensated for.

While it cannot control the external environment, the body is able to regulate the internal environment to come up with the correct response to changes in all the variables. For example, the kidneys regulate salt, water and pH; blood carries heat to all parts of the body, as well as oxygen to the cells, and removes carbon dioxide from them. All this regulation happens through homeostasis.

### The cornerstone of health

Homeostasis is at the centre of our being. It is the regulatory mechanism that keeps us alive, rather than as a mere collection of chemicals. It is what makes us biological rather than just chemical (Cedar, 2012).

The concept was first proposed by Claude Bernard in 1865 and later named by Walter Cannon (Cannon, 1926). It is often described as "the maintenance of a stable

internal environment". However, this definition tends to mean little to student health professionals; when they become qualified practitioners, the lack of connection between health and homeostasis becomes a problem for clinical practice. Understanding that homeostasis is the cornerstone of health, and its restoration the cornerstone of clinical care, is the first step in understanding the patient journey and clinical decision-making.

Homeostasis links the physiological processes (what the body does) to its cells (what the body is made of). Homeostatic mechanisms keep variables in the body at the right levels, within their normal ranges, ensuring cells survive and thrive. Homeostasis is the physiological process that maintains the internal environment in a stable, normal state. Homeostasis uses chemical and biological processes for self-maintenance.

### Adjusting to change

Humans are dynamic beings. All day long the body fluctuates: it gets hotter and colder, sweaty and dehydrated, energetic and tired. When we are healthy, we barely notice these changes, as we are able to adopt behaviours that adjust our variables and put us back in a safe place: we drink hot or cold drinks; we eat or stop eating food; we are active or rest. The motivation to change our behaviours is a consequence of internal processes working to restore us to a safe state, preventing us from getting too hot, too cold, too dehydrated or too depleted of energy.

As the external and internal environments are changing all the time, the body needs to keep the variables of its internal environment within ranges that are

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tolerable for its cells, and this is done by homeostasis. The body measures changes that occur second by second, and then sends signals to bring about further changes that will restore the stability of its internal environment and keep its variables within normal ranges. The main mechanism through which this is done is called 'negative feedback'.

### Counteracting change

Negative feedback works by opposing the direction of change. If a variable goes one way, negative feedback makes it go the opposite way to keep it as close as possible to a 'set point' (Fig 2). For example, humans' internal thermostat is set at around 37°C. If we get hotter, negative feedback mechanisms are activated to cool us down: we start to sweat so that heat evaporates from the body; the blood vessels on the surface of the skin dilate to allow heat to radiate out; we seek cool places and cool drinks. If we get too cold, negative feedback mechanisms counteract that change too: we warm up by shivering, a process in which muscles contract without moving to produce heat; the blood vessels constrict to prevent the loss of heat; we seek warmth and hot drinks.

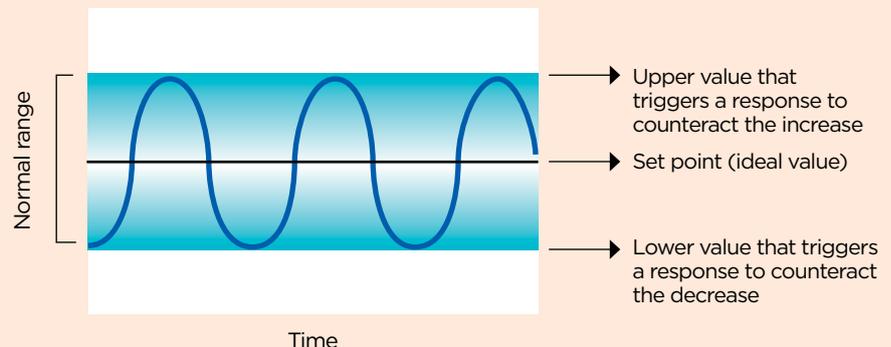
Negative feedback mechanisms do not only affect our physiology; they also affect our behaviours, motivating us to do certain things – such as drink a cool drink or put on a warm sweater. This is because most of the control centres for homeostasis reside in the brain. Outputs from the brain affect the secretion of hormones by our endocrine glands, the movement of muscles, mood, motivations and emotions.

### Amplifying change

Homeostasis is also said to work through positive feedback, where a change is promoted rather than opposed. A classic example of positive feedback is that of blood clotting following damage to a blood vessel. The damage triggers signals to factors in the blood that are normally quiescent. Once the first factor is activated, a signalling cascade ensues where a variety of factors are activated, leading to blood clotting, which allows the body to repair the damaged vessel – we do not want negative feedback to counteract these changes and stop the process. Positive feedback is goal-orientated and amplifies a change, rather than resetting a variable, however, the result is likely to be a resetting of the variable to its previous, healthy state.

Understanding of homeostasis and the states that are optimal for body cells

Fig 2. Negative feedback mechanism



When variables reach the upper or lower value in their normal range, negative feedback mechanisms push them back towards their set point (ideal value)

can be used in healthcare. This can be done empirically through the observation of humans in health and ill health, and scientifically using objective measurement.

We have seen that each variable has a 'set point' around which it fluctuates to a limited degree; mimicking nature, we have measured our variables and worked out their set points and normal ranges. When these are measured and monitored in patients they are known as vital signs.

### Signs of what is happening

Patients present with 'symptoms', or subjective feelings, such as 'feeling feverish' or 'feeling unwell'. Since these are not diagnostic of what the underlying cause could be, an objective measure is needed to ascertain what is happening. Vital signs can be measured and compared with their normal set point or range. Measurements outside the normal range indicate that something is wrong.

Table 1 lists the major vital signs monitored by nurses, with their normal values.

Table 1. Vital signs: normal values in adults

Temperature	37°C
Heart rate	60-99 beats per minute
Pulse	60-99 beats per minute
Blood pressure	120/80mmHg
Respiratory rate	12-16 breaths per minute
Oxygen saturation	95-100%
pH	7.3-7.5

Further diagnostic investigations may include:

- Electrolytes (for example, sodium, potassium, calcium);
- Blood (for example, haemoglobin, red blood cells, neutrophils, erythrocyte sedimentation rate);
- Urine (for example, glucose, creatinine).

If a vital sign, such as temperature or blood pressure, is outside its normal range, this information can be used to help diagnose the cause of the problem and decide what treatment is needed. Determining which vital signs are outside their normal range helps health professionals to locate and diagnose the underlying cause, so measuring vital signs is the basis of finding out what is wrong.

Most people have vital signs that are 'normal'. For example, we need a body temperature of around 37°C for the chemical reactions in the cells to occur, and most of us are around that temperature most of the time. However, since vigorous activity can increase body heat, the temperature should be measured when at rest – this is why patients may be asked to wait a while before their vital signs are measured if they have recently exerted themselves. If vital signs are outside the normal range at rest they are considered abnormal.

All day, each variable or vital sign fluctuates around its set point (Fig 2) – that is normal, and homeostatic mechanisms work constantly to restore them to their set point. That is homeostasis in action.

### Homeostasis in ill health

Homeostasis, which allows the body to maintain its internal environment independently of clinical support, is a measure of health. Ill health is when the body is no

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longer homeostatic (Cedar, 2012) and clinical intervention is an attempt to restore homeostasis.

When ill, the body's homeostasis is challenged too far out of the ranges within which its variables should be – beyond the limits or durations within which it can restore the variables to their set points, and we do not feel well. Often, the body can repair itself, re-establishing homeostasis. In such situations we feel subjectively unwell (symptoms) but we recover before seeking clinical help and/or obtaining objective measures (signs).

Sometimes the body cannot repair itself and needs clinical intervention to restore homeostasis. Measuring vital signs enables health professionals to ascertain which, if any, have fluctuated too far or for too long (Rose and Clarke, 2010). Clinical interventions – such as medicines, surgical procedures or respiratory support – can then be used to restore homeostasis.

### Vital signs and emergencies

In emergencies, the vital signs may be different from normal. For example, the blood pressure may have dropped due to haemorrhage, the pH may have been thrown out of balance by myocardial infarction, the osmotic balance may be altered due to kidney failure.

To assess the problem, all health professionals must act promptly, measuring vital signs to ascertain which body system is failing and ensuring these measures are accurate and comprehensive (Lord and Woollard, 2010). Rapid and frequent measurement of vital signs helps prevent pain (Elliot and Coventry, 2012) and improve the detection of causal agents.

Prompt diagnosis through the thorough assessment of vital signs enables the ailing body system to be treated promptly. This can make a significant difference, not only between life and death, but also

*“Measuring vital signs enables health professionals to ascertain which, if any, have fluctuated too far or for too long*

between a good outcome (with full restoration to health) and a poor one (with continuing problems) (Kim et al, 2017; Kenzaka et al, 2012).

### Importance of vital signs

Clinicians can assess whether patients' health is improving or deteriorating by continually monitoring their vital signs (Kim et al, 2017), which are objective measures of homeostasis. Armed with these objective measures, they can implement clinical interventions that will restore homeostasis and possibly delay death.

However, the measuring of vital signs is often incomplete and this affects outcomes. In one study of 23 Australian hospitals, 77% of patients who later experienced adverse events had at least one vital sign missing from their records (Chen et al, 2009).



### Monitoring

Clinicians can assess the state of a patient's health by monitoring vital signs

According to Mok et al (2015), nurses' attitudes to measuring vital signs is affected by their level of education and the authors conclude that “vital signs monitoring needs to be prioritized in workload planning”.

A smaller study concluded that nurses' ability to make clinical decisions was compromised by the lack of complete vital signs measurement, which led to limitations in detecting deterioration in patients (Cardona-Morrell et al, 2016). There are many other papers showing how central vital signs are to diagnosis and monitoring (Boulanger and Toghil, 2009).

It is crucial that health professionals and students understand the theory underlying vital signs, as well having the clinical skills to take the measurements (Rose and Clarke, 2010). If they see measuring vital signs as just another task and are unaware that it is central to restoring homeostasis and health then patient safety is at risk (Griffiths et al, 2015). Nurses need to appreciate that vital sign measurement is central to diagnosis, clinical decision-making, treatment and monitoring. It is not

enough to know how to measure vital signs – it is understanding what they mean and knowing why they are carried out that is significant to patient outcomes.

### Role of nurses

When clinical interventions are successful, patients are restored to as independent an existence as possible, or to how they were before seeking clinical help and becoming dependent on a clinical intervention. The role of nurses in accurately assessing vital signs and regularly monitoring them is essential, as this will ensure the correct treatments are given, recovery is promoted, homeostasis is restored and the patient returns to health. **NT**

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