SAMPLE

Temperature and Heat

From Absolute Zero to Stellar Cores

Aira Astralis

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Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

Normal human body temperature (normothermia, euthermia) is the typical temperature range found in humans, generally given as 36.5-37.5 °C (97.7-99.5 °F). Human body temperature varies. It depends on sex, age, time of day, exertion level, health status (such as illness and menstruation), what part of the body the measurement is taken at, state of consciousness (waking, sleeping, sedated), and emotions.

Body temperature is kept in the normal range by a homeostatic function known as thermoregulation, in which adjustment of temperature is triggered by the central nervous system. Taking a temperature is an initial part of a full clinical examination. There are various types of medical thermometers, as well as sites used for measurement, including:

Under the armpit (axillary temperature)

In the mouth (oral temperature)

In the rectum (rectal temperature)

In the ear (tympanic temperature)

On the skin of the forehead over the temporal artery

Using heat flux sensors

Temperature control (thermoregulation) is a homeostatic mechanism that keeps the organism at optimum operating temperature, as the temperature affects the rate of chemical reactions. In humans, the average internal temperature is widely cited as 37 °C (98.6 °F), a "normal" temperature established in the 1800s. Newer studies show that average internal temperature for men and women is 36.4 °C (97.5 °F). Temperatures cycle regularly through the day, as controlled by the person's circadian rhythm.

The lowest temperature occurs about two hours before the person normally wakes up. Temperatures also change according to activities and external factors.

Where a reading is taken matters, and the customary sites are several: the armpit (axillary), the mouth (oral), the rectum (rectal), the ear canal (tympanic), and heat-flux sensors against the skin.

In adults a review of the literature has found a wider range of 33.2-38.2 °C (91.8-100.8 °F) for normal temperatures, depending on the gender and location measured. Reported values vary depending on how it is measured:

oral (under the tongue): 36.8 ± 0.4 °C (98.2 ± 0.7 °F), internal (rectal, vaginal): 37.0 °C (98.6 °F).

Chapter 1: The Discovery of Temperature and

Heat

The customary figure quoted for healthy adults is a band between 36.5 and 37.5 °C, that is, 97.7 to 99.5 °F. Reviews of the literature, though, have found adult normals spread from 33.2 up to 38.2 °C, or 91.8 to 100.8 °F, varying with sex and with where on the body the reading is taken. Where the reading is taken matters too: an under-tongue figure differs from a rectal or vaginal one.

A rectal or vaginal measurement taken directly inside the body cavity is typically slightly higher than oral measurement, and oral measurement is somewhat higher than skin measurement. Other places, such as under the arm or in the ear, produce different typical temperatures. While some people think of these averages as representing normal or ideal measurements, a wide range of temperatures has been found in healthy people.

The body temperature of a healthy person varies during the day by about 0.5 °C (0.9 °F) with lower temperatures in the morning and higher temperatures in the late afternoon and evening, as the body's needs and activities change. Other circumstances also affect the body's temperature.

The core body temperature of an individual tends to have the lowest value in the second half of the sleep cycle; the lowest point, called the nadir, is one of the primary markers for circadian rhythms.

The body temperature also changes when a person is hungry, sleepy, sick, or cold. Body temperature normally fluctuates over the day following circadian rhythms, with the lowest levels around 4 a.m. Therefore, an oral temperature of 37.3 °C (99.1 °F) would, strictly speaking, be a normal, healthy temperature in the afternoon but not in the early morning.

An individual's temperature typically swings by roughly half a degree Celsius between its daily high and its daily low. Body temperature is sensitive to many hormones, so women have a temperature rhythm that varies with the menstrual cycle, called a circamensal rhythm. A woman's basal body temperature rises sharply after ovulation, as estrogen production decreases and progesterone increases. Fertility awareness programs use this change to identify when a woman has ovulated to achieve or avoid pregnancy.

During the luteal phase of the menstrual cycle, both the lowest and the average temperatures are slightly higher than during other parts of the cycle. However, the amount that the temperature rises during each day is slightly lower than typical, so the highest temperature of the day is not very much higher than usual. Hormonal contraceptives both suppress the circamensal rhythm and raise the typical body temperature by about 0.6 °C (1.1 °F).

Temperature also may vary with the change of seasons during each year.

This pattern is called a circannual rhythm. Studies of seasonal variations have produced inconsistent results. People living in different climates may have different seasonal patterns. It has been found that physically active individuals have larger changes in body temperature throughout the day. Physically active people have been reported to have lower body temperatures than their less active peers in the early morning and similar or higher body temperatures later in the day.

With increased age, both average body temperature and the amount of daily variability in the body temperature tend to decrease. Elderly people may have a decreased ability to generate body heat during a fever, so even a somewhat elevated temperature can indicate a serious underlying cause in geriatrics. One study suggested that the average body temperature has also decreased since the 1850s.

The study's authors believe the most likely explanation for the change is a reduction in inflammation at the population level due to decreased chronic infections and improved hygiene. Different methods used for measuring temperature produce different results. The temperature reading depends on which part of the body is being measured.

The typical daytime temperatures among healthy adults are as follows: Temperature in the rectum (rectal), vagina, or in the ear (tympanic) is about 37.5 °C (99.5 °F) Temperature in the mouth (oral) is about 36.8 °C (98.2 °F) Temperature under the arm (axillary) is about 36.5 °C (97.7 °F) Generally, oral, rectal, gut, and core body temperatures, although slightly different, are well-correlated. Oral temperatures are influenced by drinking, chewing, smoking, and breathing with the mouth open.

Mouth breathing, cold drinks or food reduce oral temperatures; hot drinks, hot food, chewing, and smoking raise oral temperatures. Each measurement method also has different normal ranges depending on sex. As of 2016, reviews of infrared thermometers have found them to be of variable accuracy. This includes tympanic infrared thermometers in children. Sleep disturbances also affect temperatures. Normally, body temperature drops significantly at a person's normal bedtime and throughout the night.

Short-term sleep deprivation produces a higher temperature at night than normal, but long-term sleep deprivation appears to reduce temperatures.

Insomnia and poor sleep quality are associated with smaller and later drops in body temperature. Similarly, waking up unusually early, sleeping in, jet lag and changes to shift work schedules may affect body temperature. A

temperature setpoint is the level at which the body attempts to maintain its temperature. When the setpoint is raised, the result is a fever.

For reference, the usual measurement spots are the underarm (axillary), the oral cavity, the rectum, the ear (tympanic), and heat-flux sensors, each carrying its own expected range.

37.6 °C (99.7 °F) — Classed as a slight fever. 35 °C (95 °F) - Threshold for hypothermia.

Shivering is absent. Reflex may be absent or very slight. 31 °C (87.8 °F) - Comatose, very rarely conscious. No or slight reflexes. The person may appear to be dead.

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ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.