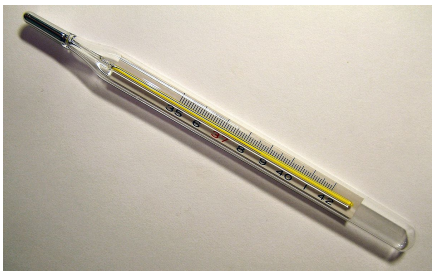
# Medical thermometer

**Medical thermometers** are used for measuring human body temperature, with the tip of the thermometer being inserted either into the mouth under the tongue (*oral* or *sub-lingual temperature*), under the armpit (*axillary temperature*), or into the rectum via the anus (*rectal temperature*).



A medical/clinical thermometer showing the temperature of 38.7 °C

## Classification by technology

### Liquid-filled

The traditional thermometer is a glass tube with a bulb at one end containing a liquid which expands in a uniform manner with temperature. The tube itself is narrow (capillary) and has calibration markings along it. The liquid is often mercury, but alcohol thermometers use a coloured alcohol. Medically, a maximum thermometer is often used, which indicates the maximum temperature reached even after it is removed from the body.

To use the thermometer, the bulb is placed in the location where the temperature is to be measured and left long enough to be certain to reach thermal equilibrium—typically three minutes. Maximum-reading is achieved by means of a constriction in the neck close to the bulb. As the temperature of the bulb rises, the liquid expands up the tube through the constriction. When the temperature falls, the column of liquid breaks at the constriction and cannot return to the bulb, thus remaining stationary in the tube. After reading the value, the thermometer must be reset by repeatedly swinging it sharply to shake the liquid back through the constriction.

#### Mercury

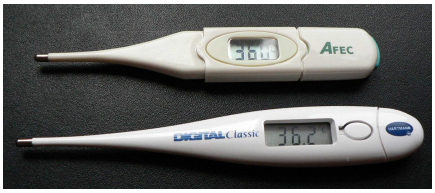
Mercury-in-glass thermometers have long been considered the most accurate liquid-filled types. However, mercury is a toxic heavy metal, and mercury has only been used in clinical thermometers if protected from breakage of the tube.

Close-up of a mercury-filled maximum thermometer. The break in the column of mercury is visible.

The tube must be very narrow to minimise the amount of mercury in it—the temperature of the tube is not controlled, so it must contain very much less mercury than the bulb to minimise the effect of the temperature of the tube—and this makes the reading rather difficult as the narrow mercury column is not very visible. Visibility is less of a problem with a coloured liquid.

In the 1990s it was decided that mercury-based thermometers were too risky to handle; the vigorous swinging needed to "reset" a mercury maximum thermometer makes it easy to accidentally break it and spill the moderately poisonous mercury. Mercury thermometers have largely been replaced by electronic digital thermometers, or, more rarely, thermometers based on liquids other than mercury (such as galinstan, coloured alcohols and heat-sensitive liquid crystals).

## Electronic



Electronic clinical thermometers

Since compact and inexpensive methods of measuring and displaying temperature became available, electronic thermometers (often called *digital*, because they display numeric values) have been used. Many display readings to great precision (0.1 °C or 0.2 °F, sometimes half that), but this should not be taken as a guarantee of accuracy: specified accuracy must be checked in documentation and maintained by periodical recalibration. A typical inexpensive electronic ear thermometer for home use has a displayed resolution of 0.1 °C, but a stated accuracy within ±0.2 °C when new.[1]

### Contact

Electronic thermometers may work by contact (the electronic sensor is placed in the location where temperature is to be measured, and left long enough to reach equilibrium). They typically reach equilibrium faster than mercury thermometers; the thermometer may beep when equilibrium has been reached, or the time may be specified in the manufacturer's documentation.

### Remote

Other electronic thermometers work by remote sensing: an infrared sensor responds to the radiation spectrum emitted from the location. Although they are not in direct contact with the area being measured, they may touch part of the body (a thermometer which senses the temperature of the eardrum without touching it is inserted into the ear canal). To eliminate the risk of patient cross-infection, disposable probe covers and single-use clinical thermometers of all types are used in clinics and hospitals.

## Basal thermometer

A basal thermometer is a thermometer used to take the basal (base) body temperature, the temperature upon waking. Basal body temperature is much less affected than daytime temperature by environmental factors such as exercise and food intake. This allows small changes in body temperature to be detected, such as those caused by ovulation[2] or changes in thyroid function.

Glass fever thermometers typically have markings every 0.1 °C or 0.2 °F. Basal temperature is stable enough to require accuracy of at least 0.05 °C or 0.1 °F, so special glass basal thermometers are distinct from glass fever thermometers. Digital thermometers which have sufficient resolution (0.05 °C or 0.1 °F is sufficient) may be suitable for monitoring basal body temperatures; the specification should be checked to ensure absolute accuracy, and thermometers (like most digital instruments) should be calibrated at specified intervals. If only the variation of basal temperature is required, absolute accuracy is not so important so long as the readings do not have large variability (e.g., if real temperature varies from 37.00 °C to 37.28 °C, a thermometer which inaccurately but consistently reads a change from 37.17 °C to 37.45 °C will indicate the magnitude of the change). Some digital thermometers are marketed as "basal thermometers" and have extra features such as a larger display, expanded memory functions, or beeping to confirm the thermometer is placed properly.

# Classification by location

The temperature can be measured in various locations on the body which maintain a fairly stable temperature (mainly sub-lingual, axillary, rectal, vaginal, forehead, or temporal artery). The normal temperature varies slightly with the location; an oral reading of 37 °C does not correspond to rectal, temporal, etc. readings of the same value. When a temperature is quoted the location should also be specified. If a temperature is stated without qualification (e.g., typical body temperature) it is usually assumed to be sub-lingual. The differences between core temperature and measurements at different locations, known as *clinical bias*, is discussed in the article on normal human body

temperature. Measurements are subject to both site-dependent clinical bias and variability between a series of measurements (standard deviations of the differences). For example, one study found that the clinical bias of rectal temperatures was greater than for ear temperature measured by a selection of thermometers under test, but variability was less.[3]

## Oral

Oral temperature may only be taken from a patient who is capable of holding the thermometer securely under the tongue, which generally excludes small children or people who are unconscious or overcome by coughing, weakness, or vomiting. (This is less of a problem with fast-reacting digital thermometers, but was certainly an issue with mercury thermometers, which took several minutes to stabilise their reading.) If the patient has drunk a hot or cold liquid beforehand time must be allowed for the mouth temperature to return to its normal value.[4]

The typical range of a sub-lingual thermometer for use in humans is from about 35°C to 42°C or 90°F to 110°F.

## Rectal

Rectal temperature-taking, especially if performed by a person other than the patient, should be facilitated with the use of lubricant (such as petroleum jelly (now discouraged) or a water-based personal lubricant). Although rectal temperature is the most accurate, this method may be considered unpleasant, or embarrassing in some countries or cultures, especially if used on patients older than young children; also, if not taken the correct way, rectal temperature-taking can be uncomfortable and in some cases painful for the patient. Rectal temperature-taking is considered the method of choice for infants.[5]

## Ear

Other kinds of medical thermometers exist, such as the tympanic thermometer that measures the temperature of the tympanum by infrared measurement, The thermometer has a projection (protected by a one-time hygienic sheath) which contains the infrared probe; the projection is gently placed in the ear canal and a button pressed; the temperature is read and displayed within about a second. These thermometers are used both in the home (models are available for prices starting at around $US20) and in medical facilities.

## Temporal artery

A newer development is the Temporal artery thermometer, which uses the infrared principle to accurately report a patient's temperature, with comparable accuracy to rectal thermometry.

## Forehead

The band thermometer is applied to the patient's brow. It is typically a band coated with different temperature-sensitive markings using liquid-crystal or similar technology; at a given temperature the markings (numerals indicating the temperature) in one region are at the right temperature to become visible. This type gives an indication of fever, but is not considered accurate.

# References

[1] Specification of typical inexpensive electronic ear thermometer (http://www.landisgyr.biz/pdfs/EarT.pdf)

[2] Weschler, Toni (2002). *Taking Charge of Your Fertility* (Revised ed.). New York: HarperCollins. ISBN 0-06-093764-5.

[3] pubmed.gov: Comparison of infrared ear thermometer derived and equilibrated rectal temperatures in estimating pulmonary artery temperatures (http://www.ncbi.nlm.nih.gov/pubmed/8797622) CONCLUSIONS: The three infrared ear thermometers studied provided a closer estimate of core body temperature than equilibrated rectal temperature. Clinical bias was greatest in febrile vs. afebrile intensive care unit patients

[4] Newman, Bruce H.; Martin, CA (2001). "The effect of hot beverages, cold beverages, and chewing gum on oral temperature". *Transfusion* **41** (10): 1241. doi:10.1046/j.1537-2995.2001.41101241.x. PMID 11606822.

[5] Fundamentals of Nursing by Barbara Kozier et al., 7th edition, p. 495

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