Glossary of terms for thermal physiology

Third Edition

revised by

The Commission for Thermal Physiology of the International Union of Physiological Sciences (IUPS Thermal Commission)

Preface

The first Glossary of Terms for Thermal Physiology was published in the *J. Appl. Physiol.* (1973, 35: 941–961) by J.Bligh and K.G. Johnson, under the auspices of the I.U.P.S. Commission for Thermal Physiology. The second revised glossary was again collated with the help of the members of the I.U.P.S Commission for Thermal Physiology and consulted experts and was published in *Pflügers Arch.* (1987, 410: 567–587) by E. Simon. Once again the members of the I.U.P.S. Commission for Thermal Physiology and consulted experts whose names are listed in APPENDIX 3 have contributed to the revision of this 3rd edition.

This revised edition obeys the following rules outlined in the first and second editions:

Units

Units used in the Glossary are based on the Système Internationale (SI). Where such units would be inconveniently small or large, SI convention permits increases or decreases by multiples of 10^3, e.g., m to mm (m × 10^{-3}) or to nm (m × 10^{-9}), but not to cm (m × 10^{-2}). The basic, supplementary, and derived SI units used in the Glossary are given in APPENDIX 1.

Symbols

The symbols used in the Glossary are listed in APPENDIX 2. These symbols conform generally to those specified in the "Proposed Standard System of Symbols for Thermal Physiology" (*J. Appl. Physiol.* 27: 439–446, 1969). Minor changes have been suggested. In the **body heat balance equation**, the symbol M is now used to denote **the rate of metabolic energy transformation (=metabolic rate); metabolic heat production** is identified by the symbol H. The symbol ε (epsilon) is used for **emissivity** and not for **emittance**, and the term **exitance** has replaced **emittance** (see American National Standard Institute, *Nomenclature and Definitions for Illumination Engineering*, RP-16, 1967, p. 32 (UDC 653.104.8:621.32)). k is used for **conductance** and λ for **thermal conductivity**.

Order of Presentation of Terms

To bring similar or related terms closer together in the Glossary, the common term is given first followed by the descriptive term, e.g., **emissivity, hemispherical**. In use the order is reversed: **hemispherical emissivity**. To avoid confusion such entries have a cross-reference, e.g., **hemispherical emissivity.** →**Emissivity**, **hemispherical**. If the same root of a term is used in more than one grammatical form, however, with analogous meaning, it is defined only once without referring explicitly to the other forms; example: **homeothermy, homeothermic, homeotherm.**

Use of Fonts and Markers in Text

Horizontal arrows in the headings of the definition point to cross-references.

Bold-face letters mark the terms and their cross-references which are being defined and, further, those terms in the text of the definitions which are defined elsewhere in the glossary.

Abbreviations

cf.	compare	OED	Oxford English Dictionary
e.g.	for example		
Fr.	French	ref	Reference
Gk.	Greek	SD	Standard Deviation
i.e.	that is	SOED	Shorter OED
L.	Latin	( )	Symbols
[ ]	Unit		

Multiple Definitions

Where more than one definition of a term is given, they are listed in order of preference.

Although this Glossary expresses the preferences of the commission, it is not a rule. It is a norm for a better communication between the scientists within the same field, scientists working in other fields and the general public. Any speciality produces its own jargon. It is hoped that this Glossary will help transform jargon into general vocabulary.

Communications concerning the glossary may be sent to the Chairman of the IUPS Thermal Commission, or to the Publisher.

Acknowledgement
This revision was initiated by James Mercer during his term as Chairman of the I.U.P.S. Commission for Thermal Physiology. Thermal Commission member Jurgen Werner was responsible for producing the first working draft and further updating of the glossary followed from numerous additional suggestions for new entries and modifications by the current commission members and other consulted experts. In the revised glossary, 11 terms have been removed, 49 of the original entries have been modified and the definitions of 37 new terms have been added, increasing the overall number of entries to 479.

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Glossary

Absolute humidity. → **Humidity, absolute.**

Absorptance, total radiant. → **Radiant absorptance, total.**

Accidental hypothermia. → **Hypothermia, accidental.**

Acclimation: Physiological or behavioral changes occurring within an organism, which reduces the strain or enhances endurance of strain caused by experimentally induced stressful changes in particular climatic factors.
Note: The terms **acclimation** and **acclimatization** are etymologically indistinguishable. Both words have been assigned several and different meanings (Greenleaf & Greenleaf, 1970). The most useful of the assigned meanings, adopted here, would seem to be those of Hart (1957) and Eagan (1963) who use the term **acclimation** to describe the adaptive changes that occur within an organism in response to *experimentally induced changes in particular climatic factors* such as ambient temperature in a controlled environment, and the term **acclimatization** to describe the adaptive changes that occur within an organism in response *to changes in the natural climate.*
Refs: Eagan, C. J., *Federation Proc.* 22: 930, 1963; Greenleaf, J.E., & C.J. Greenleaf, *NASA Tech. Mem.* X-62, 008, 1970; Hart, J.S., *Rev. Can. Biol.* 16: 133, 1957.

Acclimatization: Physiological or behavioral changes occurring within the lifetime of an organism that reduce the strain caused by stressful changes in the natural climate (e.g., seasonal or geographical). → **acclimation.**
Note: What is termed **acclimatization** may also be specified as a particular **phenotypic adaptation**; therefore, the usefulness of the term may be questioned.

Acute-phase response (APR): The multifactorial stereotyped response of an organism to infection, injury or trauma. The **APR** comprises changes in plasma concentrations of trace metals, liver proteins (so-called "acute phase proteins"), hormones, intermediary metabolism, neutrophilia, and "sickness behavior", which includes the development of **fever**, loss of food appetite, increased sleep, decreased motor activity, and decreased alertness. The **acute-phase response (APR)** is considered an early, non-specific host-defence response, and is triggered by the release of **cytokines** such as **interleukin-1** (**IL-1**), IL-6, and **tumor necrosis factor** α **(TNF**α**).**

Adaptation: Changes that reduce the physiological strain produced by stressful components of the **total environment**. This change may occur within the lifetime of an organism (phenotypic) or be the result of genetic selection in a species or subspecies (genotypic). **Acclimation** as defined in this Glossary relates to **phenotypic adaptations** to specified climatic components. In thermal physiology, the use of the term **adaptation** does not require specification of the climatic components of the **total environment** to which the organism adapts, but the most obvious component is often denoted (e.g., **adaptation** to heat). There are no distinct terms that relate **genotypic adaptations** to the climate or particular components of climate.
Note: In comparison to adaptation as defined in neurophysiology, the adaptive processes in thermal physiology usually occur with larger time constants.

Adaptation, genetic. → **Adaptation, genotypic.**

Adaptation, genotypic: A genetically fixed condition of a species or subspecies, or its evolution, which favours survival in a particular **total environment**. → **adaptation.**

Adaptation, nongenetic. → **Adaptation, phenotypic.**

Adaptation, phenotypic: Changes that reduce the physiological and/or emotional strain produced by stressful components of the **total environment** and occurring within the lifetime of the organism. Synonym: **adaptation, nongenetic.**
Note: **acclimation** relates to **phenotypic adaptation** to individual climatic components of the **total environment.**

Aestivation. → **Estivation.**

Afebrile: The thermoregulatory state of an organism where **core temperature** is normal, and thermoeffectors are not attempting to increase or maintain **core temperature** at an elevated level. Antonym: **febrile**

Alliesthesia: Generally, the changed perception of a given peripheral stimulus resulting from the stimulation of internal sensors; in thermal physiology, the dependence of thermal sensation on both skin and **core temperatures**. (Gk.*alloioo*-to alter; *aisthesia*-sensation)
Note: Positive **alliesthesia** indicates a change to a more pleasurable sensation, *negative* **alliesthesia** a change to a less pleasurable one.

Ambient temperature. → **Temperature, ambient.**

Anaerobic metabolism. → **Metabolism, anaerobic.**

Anapyrexia: A pathological condition in which there is a regulated decrease in **core temperature**. **Anapyrexia** is distinct from **hypothermia** in that thermoregulatory responses indicate a defence of the **anapyretic** level of **core temperature**. (Gk. *ana*-reverse; *pyretos*-fever).
Note: **Anapyrexia** may be caused by exogenous or endogenous substances (→ **Cryogen**); e.g., the activation of heat loss underlying the **menopausal hot flushes** may be considered as due to temporary **anapyrexia** caused by GnRH.

Antipyretics, endogenous: Hormones and **cytokines** that limit the magnitude of **fever**. The hormones include arginine vasopressin (AVP), α-melanocyte stimulating hormone (αMSH), and glucocorticoids. The **cytokines** IL-4, **IL-1**α and possibly **TNF-**α (under some conditions) are also **endogenous antipyretics**. All, however, have distinct mechanisms of action.

Antipyretics, exogenous: Pharmacological agents (e.g.,cyclooxygenase inhibitors [NSAID's]) that prevent or attenuate the development of **fever**.

Area, DuBois (A_D): The total surface area in square meters of a nude human as estimated by the formula of DuBois based on the height, H[m], and mass, W[kg]. Ref.: DuBois, E.F., *Basal Metabolism in Health and Disease*, Philadelphia, P.A, Lea & Febiger, 1927. $A_D = 0.202 \cdot W^{0.425} \cdot H^{0.725}$ [m^2]

Area, effective radiating (A_r): The surface area of a body that exchanges **radiant energy** with the environment through a solid angle of 4 π steradians. [m^2]

Area, projected (A_p): The area of a body (or surface) projected on a plane perpendicular to the direction of a collimated beam (projected through an aperture) of radiation. [m^2]

Area, solar radiation (A_s): The area of a body projected perpendicularly to the sun's rays. [m^2]

Area, total body (A_b): The area of the outer surface of a body, assumed smooth. [m^2]
Note: Direct measurements of surface area are difficult and subject to appreciable error. Surface area is usually estimated from a formula such as that of Meeh (1879) that relates **total body area** (**A_b**) to body weight (W): $A_b = k \cdot W^{2/3}$. This is a particular case of Huxley's allometric law. Estimates of the value of k vary widely between and within species but are generally between 0.07 and 0.11 when **A_b** is in m^2 and W is in kg (Spector, 1956). The DuBois formula (→**Area, DuBois**), used in the estimation of the **total body area**, relates **total body area** to both mass and height. Estimates of **total body area** made with either Meeh's formula or the DuBois formula have limited accuracy, and reference should be made to the original direct measurements from which **total body area** was calculated. Refs: Huxley, J.S., *Problems of Relative Growth,* London: Methuen, 1932; Meeh, K., Z. *Biol.* 15: 425, 1879; Spector, W.S., *Handbook of Biological Data*, Philadelphia, P.A.: Saunders, 1956.

Area, wetted (A_w): The area of skin which, if covered with sweat (water), would provide the observed rate of evaporation under the prevailing condition. [m^2] → **Wettedness, skin**.

Autonomic temperature regulation. → **Temperature regulation, autonomic.**

Autonomic thermoregulation. → **Temperature regulation, autonomic.**

Bacterial pyrogen. → **Pyrogen, bacterial.**

Basal metabolic rate. → **Metabolic rate, basal.**

Behavior, thermoregulatory. → **Temperature regulation, behavioral.**

Behavioral temperature regulation. → **Temperature regulation, behavioral.**

Behavioral thermoregulation. → **Temperature regulation, behavioral.**

Blackbody. → **Radiator, full.**

Body heat balance: The steady-state relation in which total **heat gain** in the body equals its **heat loss** to the environment.

Body heat balance equation (actually: **heat flow balance equation**)**:** A mathematical expression that describes the net rate at which a subject generates and exchanges heat with its environment (First Law of Thermodynamics). The dimension of the equation and its terms respectively, are in watts [W] thereby constituting **heat flows**, but often are also expressed in relation to unit area of body surface [$W \cdot m^{-2}$], to unit body mass [$W \cdot kg^{-1}$], or to unit body volume [$W \cdot m^{-3}$].

$S = M - (W) - (E) - (C) - (K) - (R).$

S = **storage of body heat** (positive = increase in **body heat content**; negative = decrease in **body heat content**).
M = **metabolic energy transformation** (always positive in a living organism) = **metabolic rate.**
W = **work rate, positive** (= **useful mechanical power accomplished**; negative = mechanical power absorbed by body: **work rate, negative**).
E = **evaporative heat transfer** (positive = **evaporative heat loss**; negative = **evaporative heat gain**).
C = **convective heat transfer** (positive = transfer to the environment; negative = transfer into the body).
K= **conductive heat transfer** (positive = transfer to the environment; negative = transfer into the body).
R = **radiant heat exchange** (positive = heat transfer to the environment; negative = heat absorption by the body).
Note: The equation is designed to describe the prevailing physiological situation of a **homeothermic** (e.g. human) subject. At a given **metabolic energy transformation**, the subject transfers some mechanical energy to its ambiance (→**work rate, positive**), and, if the ambient thermal conditions permit it, heat from the body to the environment by evaporation, conduction, convection, and radiation, which eventually results in the stabilization of **body heat content** with storage S = 0. However, there are physiological conditions in which mechanical energy is absorbed by the body, ultimately as heat (→**work rate, negative**), and/or one or the other of the terms describing the exchange of **heat flow** with the environment may become negative.
In a **core**/**shell** treatment of the body we get two **heat balance equations**:
$S_{core} = M - (W) - (H) - REHL$
$S_{shell} = H - (E) - (C) - (R) - (K)$
with $REHL$ = → **respiratory evaporative heat loss *(REHL)*** and H = → **heat transfer** (conductive and convective heat flow) between **core** and **shell**. The latter is proportional to the difference of mean **core** and **mean skin temperature** with the proportionality constant → **conductance k.**

Body heat content. → **Heat content, body.**

Body heat storage. → **Storage of body heat** and **Heat storage, change in.**

Body temperature, mean. → **Temperature, mean body.**

Bradymetabolism: The low levels of **basal metabolism** of reptiles and other nonavian and nonmammalian animals relative to those of birds and mammals of the same body size and at the same tissue temperature. (Gk. *bradus*-slow, sluggish; *metabole*-change) Antonym: **tachymetabolism.**
Note: As a synonym **cold-blooded**ness is unsatisfactory and is falling into disuse. This relatively low level of **basal metabolism** is sometimes described as **poikilothermy**, which is incorrect since **poikilothermy** signifies conformity of **body** and **ambient temperatures** and not all **bradymetabolic** species are **temperature conformers**; some are **ectothermic temperature regulators**.

Brain cooling, selective. → **Selective brain cooling.**

Brown adipose tissue (BAT): A particular form of ad-

ipose tissue with selected distribution. It differs from white adipose tissue both structurally and functionally; its colour is brownish (yellow to reddish), depending on its content of (mitochondrial) cytochromes and of fat which is distributed in multipledroplets (multilocular) as compared to white fat cells (monolocular) and also on its dense vascularization. **Brown adipose tissue** appears to be restricted to mammalian species, especially of smaller body size, including the hibernators (→ **Hibernation**), but is also present in newborns of larger species including humans. Regulatory heat production has been identified as its main but possibly not its only function. Its heat-generating capacity relates to the rate of fatty acid oxidation which is not constrained by cellular ATP catabolism. This property correlates with the presence of a specialized component in the inner mitochondrial membrane named **UCP1** (the **uncoupling protein** or **thermogenin**, which establishes a proton shunt bypassing oxidative phosphorylation). The activity of **brown adipose tissue** is controlled by the sympathetic nervous system through release of adrenaline.
Note: Chronic exposure to cold (→ **nonshivering thermogenesis**) and to excess food intake (→ **diet-induced thermogenesis**) enhance the heat-generating capacity of **brown adipose tissue** by hypertrophy (including increase in **UCP1** amount) and hyperplasia. The total process is referred to as recruitment. In accordance with the sympathetic control of **brown adipose tissue**, the increase in **metabolic energy transformation** of an animal in a **thermoneutral** environment after systemic injection of noradrenaline is considered as an estimate of the thermogenetic capacity of **brown adipose tissue**.

Brown fat. → **Brown adipose tissue.**

Calorimetry: The measurement of heat. In thermal physiology, the measurement of the **heat transfer** between a tissue, an organ, or an organism and its environment. (L. *calor*-heat; Gk. *metria*-act of measuring) → **calorimetry, direct and calorimetry, indirect**.

Calorimetry, direct: The direct physical measurement of heat, usually the rate of transfer of heat **(→ heat transfer**) between a tissue, an organ, or an organism and its environment.

Calorimetry, indirect: The measurement of the rate of transfer of a material involved in the transformation of chemical energy into heat between a tissue, an organ, or an organism and its environment. The process requires the calculation of the **heat transfer** from an empirically established relation between the material transfer and the **heat transfer**.
Note: The most common method of **indirect calorimetry** is to measure the uptake of oxygen and/or the elimination of carbon dioxide, and to convert these values to an equivalent quantity of heat. The calorific equivalent of a litre of oxygen is approximately 20 kJ of heat.

Calorimetry, partitional: The estimation of any single term in the **body heat balance equation** from direct measurements of all other terms in the equation during the steady state. Ref: Winslow, C.E.A., L.P. Herrington, & A.P. Gagge, *Am. J. Physiol.* 116: 641, 1936.

Cenothermy: The condition of a **temperature regulator** when its **core temperature** is within $\pm$1 SD of the range associated with the normal postabsorptive resting condition of the species in the **thermoneutral zone**. (Gk. *koinos*-common, shared; *therme*-heat) Synonym: **euthermy, normothermy**.
Note: Ceno (common) seems a more appropriate prefix than *eu* (well, good).

Change in heat storage. → **Heat storage, change in.**

Chemical temperature regulation. → **Temperature regulation, chemical.**

Circadian: Relating to the approximate 24-h periodicity of a free running biological rhythm, or to the exact 24-h periodicity of an environmentally synchronized biological rhythm that persists with an approximate 24-h periodicity when not environmentally synchronized. (L. *circa*-about, approximately; *dies*-day)

clo: A unit to express the relative **thermal insulation** values of various clothing assemblies.
$1 \text{ clo} = 0.18°\text{C}\cdot\text{m}^2\cdot\text{h}\cdot\text{kcal}^{-1} = 0.155°\text{C}\cdot\text{m}^2\cdot\text{W}^{-1}$

Note: The **clo** is a unit developed to express **thermal insulation** (→ **thermal resistance**) in practical terms and represents the **insulation** provided by the normal indoor clothing of a sedentary worker in comfortable indoor surroundings (Ref: Gagge, A.P., A.C. Burton, & H.C. Bazett, *Science* 94: 428, 1941). The term is used in heating and ventilation engineering in the determination of environmental conditions for human comfort.

Cold-blooded: The thermal state of an animal in which **core temperature** remains close to **ambient temperature** when subjected to a low **ambient temperature**. Synonym: **bradymetabolic, poikilothermic**. Antonym: **warm-blooded.**

Note: The existence of only a small temperature gradient between the organism and its environment results from the low rate of **metabolic heat production** (**bradymetabolism**) of **cold-blooded** animals relative to the high rate of **metabolic heat production** (**tachymetabolism**) of **warm-blooded** animals. Thus, the terms **bradymetabolic** and **tachymetabolic** are preferred to the terms **cold-blooded** and **warm-blooded**, because the first pair of terms relates to a more basic physiological distinction and because the second pair of terms has been used with various meanings not all of which are entirely consistent with the definitions given here. Since their **core temperatures** follow ambient temperature, all **cold-blooded** animals are **poikilothermic** (i.e., many temperatured). Thus, **cold-blooded**, **poikilothermic**, and **bradymetabolic** are descriptions of related phenomena. The same cannot be said of **warm-blooded**, **homeothermic**, and **tachymetabolic** (→ **warm-blooded**).

Cold receptor. → Thermoreceptor.

Cold tolerance: The ability to tolerate low **ambient temperatures**. This term comprises a variety of physiological properties. Certain **homeotherms (tachymetabolic** species) are described as **cold tolerant**, because they are able to balance heat production and **heat loss** in the state of **cenothermy** at particularly low **ambient temperatures**. This may be due to the development of **insulation** or to the efficiency of **metabolic heat production** and is often combined with an improved ability to protect appendages from freezing by effective vascular control of **local heterothermy**. In **homeotherms**, **cold tolerance** may also be achieved by general **heterothermy**, including **hibernation,** i.e., by controlled forms of **hypothermia**. **Poikilotherms (bradymetabolic** species) are characterized as **cold tolerant**, if they are able to survive low and even subfreezing body temperatures, either in the state of **cryothermy,** or because intracellular formation of ice crystals is avoided during freezing. All forms of **cold tolerance** may be subject to **adaptation** or **acclimat(izat)ion.**
Note: While some types of what is termed **cold tolerance** have already been specified (**cryothermy, hibernation**), further specification and agreement upon additional definitions seem necessary.

Combined nonevaporative heat transfer coefficient. → Heat transfer coefficient, combined nonevaporative.

Comfort. → Thermal comfort.

Conductance, thermal. → Thermal conductance.

Conductive heat transfer (K): The net rate of **heat transfer** in a solid material or a non-moving gas or fluid (i.e., by conduction) down a thermal gradient, within an organism, or between an organism and its external environment. The latter is usually expressed in terms of unit area of the total body surface, i.e. as a **heat flux**, and is the quantity (K) in the **body heat balance equation** in which ($-K$) = **heat gain**, and ($+K$) = **heat loss**. [$W \cdot m^{-2}$], [W], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$]

Conductive heat transfer coefficient. → Heat transfer coefficient, conductive.

Conductivity, thermal. →Thermal conductivity.

Control: 1. the process by which a physiological variable becomes a function of information generated locally or transmitted from remote sources by neural or hormonal signals (feedforward control); 2. the process by which a physiological system stabilizes ("regulates") a variable, generally by means of an information loop with negative feedback. The control loop comprises the controlled (passive) system (e.g., the **heat transfer** processes) and the controlling (active) system, which may be divided into sensor, processor and effector components.
Note: With the adoption of definition #2 from the terminology of technical control, further terms like **set-point**, controlled variable, load-error, negative-feedback, servo-control, etc., have been introduced to describe the various components of the physiological processes of **regulation**. **Control** in the sense of definition #2 and **regulation** are analogous terms in physiology. However, the use of the term **regulation** should be generally given preference in order to avoid confusion between the two definitions of **control**.

Control, proportional: A control concept with negative feedback, obviously present in **thermoregulation**, in which the controller activates **thermoeffector** mechanisms to an extent dependent on the deviation of the controlled variable from its **set-point**. If the disturbance (external or internal thermal load) persists, such a control concept implies a load error, i.e., a permanent deviation of the controlled variable. However, such a deviation is much smaller than that which is present without feedback control.

Controlled temperature lability. → **Temperature lability, controlled.**

Convection, circulatory: Flow of blood in the vessels of the circulatory system. In thermal physiology, convective transfer of heat with the blood stream from the **thermal core** through the **thermal shell** to the heat dissipating surfaces of the body is a **thermoeffector** of **autonomic temperature regulation**. Its efficiency in transferring heat is a function of flow rate and the temperature gradient between **core** and heat dissipating surface, and may be modified by the degree of heat exchange by conduction between the vessels to and from these surfaces (e.g., due to the counter-current arrangement of arteries and veins).

Convective heat transfer (*C*): The net rate of **heat transfer** in a moving gas or fluid (i.e., by convection) between different parts of an organism, or between an organism and its external environment; it may develop and be amplified by thermal gradients (natural convection) and by forces such as wind, fans, pumps or body movement (forced convection) usually expressed in terms of unit area of the total body surface (→ **Area, total body**), i.e., as a **heat flux**. The quantity (C) in the **body heat balance equation** in which ($-C$) = **heat gain** and ($+C$) = **heat loss**. [$W \cdot m^{-2}$], [W], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$]

Convective heat transfer coefficient.→ **Heat transfer coefficient, convective.**

Convective mass transfer. → **Mass transfer, convective.**

Convulsions, febrile: Convulsions (epileptic seizures) occurring before or during **fever** episodes. **Febrile convulsions** occur mostly in children between the age of 6 months and 3 years. They are rare after the age of 8 years.
Note: Due to its rare occurrence, this term has become obsolete in many developed countries.

Core temperature. → **Temperature, core.**

Core, thermal: Those inner tissues of the body whose temperatures are not changed in their relationship to each other by circulatory adjustments and changes in heat dissipation to the environment that affect the **thermal shell** of the body.
Note: The term is used mainly to describe the deep body tissues of **homeotherms** whose temperatures are represented by the **core temperature**. The brain is generally a section of the **thermal core**: however, in several mammalian and avian species its temperature may deviate to some extent from that of the remaining **thermal core** due to **selective brain cooling**.

Crepuscular: Occurring daily during the phases of twilight. → **diurnal**. (L. *crepusculum*-twilight) .

Critical temperature for evaporative heat loss. → **Critical temperature, upper.**

Critical temperature for heat production.→ **Critical temperature, lower.**

Critical temperature, lower: The **ambient temperature** below which the rate of **metabolic heat production** of a resting thermoregulating **tachymetabolic** animal must be increased by **shivering** and/or **nonshivering thermogenesis** in order to maintain thermal balance. Synonym: **critical temperature for heat production**. [°C]

Critical temperature, upper: The **ambient temperature** above which the rate of **evaporative heat loss** of a resting **thermoregulating** animal must be increased (e.g., by **thermal tachypnea** or by **thermal sweating**) in order to maintain thermal balance. Synonym: **critical temperature for evaporative heat loss**. [°C]
Note: **Upper critical temperature** has also been used to define the **ambient temperature** above which the capacities of the mechanisms of **heat transfer** to the environment of a resting animal are exceeded, such that **core temperature** is forced to rise and, as a consequence, **metabolic energy transformation**, i.e., the internal heat load, is further increased. This use of the term should be avoided, however, because it does not accurately describe the **upper temperature survival limit**.

Cryogen: An endogenous or exogenous substance that lowers the **set-point** of body temperature and causes **anapyrexia**. Antonym: **pyrogen**. (Gk. *kruos*-cold; < *gen*-become).

Cryothermy: The thermal status of a supercooled organism (i.e., with the temperature of the body mass below the freezing point of the tissue). (Gk. *kruos*-cold; *therme*-heat)

Cutaneous evaporative heat loss *(CEHL)*: Rate of heat dissipated by evaporation from the skin. [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$]. **Cutaneous evaporative**

heat loss *(CEHL)* plus **respiratory evaporative heat loss *(REHL)*** constitute → **evaporative heat loss.**

Cutaneous water exchange, passive. → Passive cutaneous water exchange.

Cutaneous water vapor exchange, passive. → Passive cutaneous water vapor exchange.

Cytokine: A class of immunoregulatory polypeptides produced by various cell types, but, at the outset, primarily by mononuclear phagocytes activated by various signals provided by **exogenous pyrogens**. **Cytokines** may act as endogenous mediators of fever (**endogenous pyrogens**). The most prominent among the **fever** producing **cytokines** are **interleukins (IL)**-1β and -6, **tumor necrosis factor (TNF)-α,** and interferon (IFN)-α.

Deep body temperature. → Temperature, core.

Density (ρ): The ratio of the mass to the volume of a substance. [$kg \cdot m^{-3}$]

Dew-point temperature. → Temperature, dew-point.

Diet-induced thermogenesis. → Thermogenesis, diet-induced.

Diffusivity, mass (D): The constant of proportionality relating the rate of diffusion of a gas to the gradient of its concentration in another gas, e.g., water vapor in air. If the rate of diffusion of mass is $\dot{m}$[$kg \cdot s^{-1}$] in a direction specified by a coordinate y [m] and if the concentration over a plane at a given value of y is p[$kg \cdot m^{-3}$], the rate of flow through an area A is given by the Fickian equation, $\dot{m} = -DA\,(\partial p/\partial y)$, where D is the **mass diffusivity** or diffusion coefficient and $\partial p/\partial y$ is the appropriate concentration gradient. More complex equations are needed to describe diffusion in two or three directions simultaneously [$m^2 \cdot s^{-1}$]

Diffusivity, thermal (α): The **thermal conductivity** of a substance divided by its density (ρ) and **specific heat** at constant pressure (c_p) ·[$m^2 \cdot s^{-1}$]

Direct calorimetry. → Calorimetry, direct.

Directional emissivity. → Emissivity, directional.

Diurnal: 1. Indicates biological processes (e.g., phases of activity) occurring during the day, as distinct from the night. 2. Occurring daily (during each 24-h period). (L. *diurnus* adj < *dies*-day).
Note: Terms relating to other phases of entrained 24 h periodicity, i.e., to definition #1, are: **nocturnal** (during the night) and **crepuscular** (during twilight); **nychthemeral** corresponds to definition #2.

Dry bulb temperature. → Temperature, dry bulb.

Dry heat loss. → Heat loss, nonevaporative.

DuBois area. → Area, DuBois.

Eccritic body temperature. → Preferred body temperature.

Ectothermic temperature regulator. → Temperature regulator.

Ectothermy: The pattern of **temperature regulation** of animals in which body temperature depends mainly on the behaviorally controlled exchange of heat with the environment. Autonomic **thermoeffectors** may be temporarily important in a few **ectothermic** species (panting in lizards, warming-up of insects). (Gk. *ektos*-outside; *therme*-heat) Antonym: **endothermy**.

Effective radiant field. → Radiant flux, effective.

Effective radiant flux. → Radiant flux, effective.

Effective radiating area. → Area, effective radiating.

Effective temperature. → Temperature, effective.

Emissivity (ε): The ratio of the total **radiant energy** emitted by a body to the energy emitted by a **full radiator** at the same temperature.

Emissivity, directional ($\varepsilon_{(\theta,\phi)}$): The ratio of the **thermal radiance** ($L_{e,th}$) of a body in a given direction to that of a **full radiator** ($L_{e,(\varepsilon=1)}$) at the same temperature. $\varepsilon_{(\theta,\phi)} = L_{e,th(\theta,\phi)}/L_{e,(\varepsilon=1)}$ in which θ and ϕ are the angular coordinates defining the given direction.

Emissivity, hemispherical (ε_h): The ratio of the total **radiant energy** emitted by an element of a surface into a hemisphere to the energy by a similar element on the surface of a **full radiator**. The element forms the center of the equatorial plane of the hemisphere, but it is not necessary to define its radius.

Emissivity, spectral (ε_λ): The ratio of the **radiant flux** emitted by an element of surface per unit wavelength interval to the flux emitted by a **full radiator** at the same temperature and in the same waveband.

Emissivity, window (ε_w): The ratio of the **radiant energy** emitted by an element of surface between wavelength λ_1 and λ_2 to the flux emitted by a **full radiator** at the same temperature and in the same waveband. The quantity is a special type of **spectral emissivity** and is used because some biological materials have a low **emissivity** in parts of the infrared or visible spectrum. These parts are known as windows.

Emittance. → **Radiant exitance.**

Endogenous antipyretic. → **Antipyretic, endogenous.**

Endogenous pyrogen. → **Pyrogen, endogenous.**

Endothermic temperature regulator. → **Temperature regulator.**

Endothermy: The pattern of **thermoregulation** in which the body temperature depends on a high (**tachymetabolic**) and controlled rate of **heat production**. Behavioural responses are often used by **endotherms**. (Gk. *endo*-inside; *therme*-heat) Antonym: **ectothermy**.
Note: The use of **endothermy** to denote the production of heat within an organ or organism is etymologically correct but may be found confusing as the same term is used in chemistry to mean the *uptake* of heat during a chemical reaction.

Endotoxin: Heat stable compounds that are intrinsic to the cell walls of Gram-negative bacteria. The term derives from the noxious effects on the infected host; in addition, endotoxins act as potent **exogenous pyrogens** and stimulators of the **acute-phase response**, respectively. **Endotoxins** contain lipopolysaccharides (LPS) of high molecular weight. Other cell wall components, e.g., peptidoglycans, may have partially similar effects.

Energy: Energy may occur either as chemical, electromagnetic, or mechanical energy. [Ws = J]. Synonymous to mechanical energy (force times length, height or distance) is work, synonymous to thermal energy is heat. Work or heat per unit time **(→ work rate** or → **heat flow)** constitute physically → **power**, and are used as components in the **body heat balance equation**.

Energy metabolism. → **Metabolism, energy.**

Environment. → **Total environment.**

Estivation: A state of lethargy (often during the summer) with a reduction in body temperature and **metabolism** demonstrated by some animals that are **temperature regulators** when active. The term is usually, but not exclusively, applied to **ectothermic temperature regulators**. (L. *aestivus* adj < *aestas*-summer)

Eurythermy: The tolerance by organisms of a wide range of environmental temperatures, or the accommodation to substantial changes in the thermal environment. (Gk. *eurus*-wide; *therme*-heat) Antonym: **stenothermy**.

Euthermy. → **Cenothermy.**

Evaporative heat gain: → **evaporative heat transfer** from the ambiance to the body (i.e., gain of heat energy) due to condensation of vapor on the skin and/or the surfaces of the respiratory tract, usually expressed in terms of energy per unit time and unit area of total body surface. [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$]
Note: **evaporative heat transfer** most frequently occurs by vaporization of water from body surfaces and is → **evaporative heat loss**.

Evaporative heat loss: → **evaporative heat transfer** from the body to the ambiance (i.e., loss of heat energy) by evaporation of water from the skin and the surfaces of the respiratory tract, usually expressed in terms of **heat flow** [W] or **heat flux** [$W \cdot m^{-2}$] (energy per unit time and unit area of total body surface) or in [$W \cdot kg^{-1}$] or [$W \cdot m^{-3}$].
Note: **Evaporative heat loss** comprises passive components, i.e., water vaporizing from respiratory surfaces at normal respiration and water diffusing through the skin and vaporizing at the surface (→ **insensible perspiration**); its thermoregulatory components are established by autonomic **thermoeffectors**, like **thermal sweating** and **thermal panting**, and behavioral **thermoeffectors**, like **saliva spreading, wallowing**, and other modes of behavioral surface wetting.

Evaporative heat loss coefficient. → **Heat loss coefficient, evaporative.**

Evaporative heat loss, respiratory. → **Respiratory evaporative heat loss.**

Evaporative heat transfer (*E*): The rate at which heat energy is transferred by evaporation from or condensation on the skin and the surfaces of the respiratory tract, usually expressed in terms of unit area of total body surface. The quantity (***E***) in the **body heat balance equation**, evaporation and heat loss from the body are indicated by (+*E*), condensation and **heat gain** to the body by (–*E*). [W] or [$W \cdot m^{-2}$].

Exertional heat stroke: An acute syndrome caused by an excessive rise in body temperature as the result of overloading or failure of the thermoregulatory system during exposure to heat stress while exercising in a warm environment.
Note: **Exertional heat stroke**, in contrast to classical **heat stroke**, occurs most commonly in healthy young or middle-aged adults; cutaneous vasodilatation is reduced and **thermal sweating** may decrease but is often still conspicuous.

Exitance. → **Radiant exitance.**

Exogenous pyrogen. → **Pyrogen, exogenous.**

Febrile: A term used to describe the state of an organism during a **fever**. Antonym: **afebrile**

Febrile convulsions. → **Convulsions, febrile.**

Fever: A state of elevated **core temperature** which is often, but not necessarily, part of the defensive responses of organisms (host) to the invasion by live (microorganisms) or inanimate matter recognized as pathogenic or alien by the host. The rise in **core temperature** is usually designated as due to a change in the thermocontroller characteristics resulting in an elevation of the **set-point** of body temperature. The higher temperature is actively established and defended by the operation of heat-producing and heat-conserving **thermoeffectors**. Time courses and extent of natural **fevers** are variable, but an upper temperature limit (41°C in humans) is seldom exceeded, at which level **core temperature** is maintained for some time and eventually reduced when the **set-point** of **temperature regulation** returns to its normal level. While any rise in body temperature may be due to **fever**, those rises which are not accompanied by supportive changes in **thermoeffector** activities, are termed **hyperthermia**. The humoral mechanisms underlying **fever** consist of the alteration of the neural control of body temperature by agents named **pyrogens**. **Endogenous pyrogens** (e.g., prostaglandin E_2) are usually the obligatory mediators of **fever**, but direct actions of **exogenous pyrogens** are not ruled out. **Fever** can also result as an idiopathic condition of the body. It can also be caused by emotional stress (→ **stress fever**). The exact mechanisms of **fever** induction are not yet clear.
Note: Typical natural **fever** in response to bacterial infection is induced by **interleukin-1** (**IL-1**), IL-6 and other **cytokines** which are formed as mediators in the multifactorial humoral host-defence response termed **acute-phase response**. Limited **febrile** rises in **core temperature** are apparently harmless, as long as bodily functions are not compromised by other disturbances or stressful conditions. **Fever** may contribute to the beneficial effects of the humoral host-defence responses to infection.

Fever, stress. → **Stress fever.**

Freezing cold injury (FCI): Tissue damage (frostbite) resulting when tissue temperature falls below its freezing temperature (ca. –2°C). 90% of **FCI's** occur in exposed skin and the extremities. The development of **FCI** is primarily determined by the **ambient temperature**, Antonym: **Non-freezing cold injury (NFCI).**

Full radiator. → **Radiator, full.**

Genetic adaptation. → **Adaptation, genotypic.**

Genotypic adaptation. → **Adaptation, genotypic.**

Globe temperature. → **Temperature, globe.**

GDP-binding protein. → **UCP1.**

Gular fluttering: The rapid oscillations of the hyoid apparatus and hence of the gular region of some birds as a characteristic form of **thermal panting** during exposure to high **ambient temperature**, by which means air is moved across the moist surfaces of the upper respiratory tract.

Habituation: Reduction of responses to or perception of a repeated stimulation.

Heat. → **Energy.**

Heat balance equation. → **Body heat balance equation.**

Heat capacity: The product of the mass of an object and its **specific heat**. [J ·°C^{-1}]

Heat content, body: The product of the body mass, its average **specific heat**, and the absolute **mean body temperature**. [J]
Note: The actual value of this term is seldom calculated. It is used only in the determination of **heat storage. → Storage of body heat.**

Heat cramps: Painful spasms of skeletal muscles related to prolonged heat stress.
Note: **Heat cramps** are usually strong painful tetanic contractions of groups of extremity or abdominal muscles. They are related to prolonged heat stress, profound **thermal sweating** and water but not salt deficit replacement.

Heat endurance.→ Heat toleranc.

Heat exhaustion: Muscular weakness, fatigue, and distress, resulting from prolonged exposure to heat. **Core temperature** is elevated and **thermal sweating** and cutaneous vasodilatation are commonly but not invariably reduced. This condition is aggravated by muscular exertion, dehydration and hyponatremia. Circulatory abnormalities may occur.

Heat flow [*H*]: The amount of **heat transferred** per unit time between parts of a body at different temperatures, or between a body and its **environment** when at different temperatures. [W]. Physically it constitutes → **power.**

Heat flow balance equation.→ Body heat balance equation.

Heat flux: Heat flow passing through unit area of a given surface. [W · m^{-2}]

Heat gain. → Heat transfer.

Heat loss. → Heat transfer.

Heat loss coefficient, evaporative. → Heat transfer coefficient, evaporative.

Heat loss, dry: The sum of **heat flows** or **heat fluxes** by radiation, convection, and conduction from a body to the **environment**. [W] or [W · m^{-2}] Synonyms: **sensible heat loss; heat loss, Newtonian**.
Note: In meteorological literature, **sensible heat loss** refers to convection only and does not include other forms of **heat transfer**.

Heat loss, evaporative. → Evaporative heat loss.

Heat loss, insensible. → Evaporative heat loss.
Note: The term **insensible heat loss** should be avoided in favour of **evaporative heat loss**, because of possible confusion with **insensible water loss** which implies **evaporative heat loss** but relates to fluid balance.

Heat loss, Newtonian. → Heat loss, dry.

Heat loss, nonevaporative. → Heat loss, dry.

Heat loss, sensible. → Heat loss, dry.

Heat production, metabolic. → Metabolic heat production.

Heat production (excess), postprandial: The *increase* in **metabolic heat production**, relative to its postabsorptive resting level, in the hours following food intake. Its relationship to **specific dynamic effect**, or **diet-induced thermogenesis** is not clear.
Note: While the term **postprandial heat production** is coming into use, it is recommended to include the specification **excess**, because the definition means heat production in excess of **resting metabolic rate *(RMR)***.

Heat production, total. → Total heat production.

Heat shock protein (HSP): Intracellular proteins present in every species, from bacteria to humans. Among the multiple functions ascribed to these proteins they protect nascent proteins, halt proteins de-folding etc. Their generation may alter the threshold for thermal injury.

Heat shock response. → Thermotolerance.

Heat, specific. → Specific heat.

Heat storage, change in: → Storage of body heat.

Heat stroke: An acute syndrome caused by an excessive rise in **core temperature** as the result of overloading or failure of the thermoregulatory system during exposure to heat stress. It is characterized by a large variety of pathophysiological alterations of bodily functions, including mental disturbances, with a high incidence of permanent or fatal damage.

Note: Classical **heat stroke**, in contrast to **exertional heat stroke**, occurs under sedentary conditions, most commonly in very old or very young people; cutaneous vasodilatation is greatly reduced and **thermal sweating** is commonly absent.

Heat syncope: Collapse, usually with loss of consciousness, during exposure to heat. The symptoms are similar to those of the vasovagal syndrome (fainting).

Heat tolerance: The ability to tolerate high **ambient temperatures**. This term comprises a variety of physiological characteristics. **Homeotherms** (**tachymetabolic** species) are often characterized as **heat tolerant**, if they remain comfortable or are able to balance heat production and **heat loss** at particularly high **ambient temperatures**. **Homeothermic** species are also characterized as **heat tolerant**, if they are capable to maintain normal functions, or to survive, at body temperatures exceeding their normal range; this may involve the facility of **selective brain cooling**. – **Poikilotherms** (**bradymetabolic** species) may also be specified as **heat tolerant**, if they are able to survive very high body temperatures. All forms of **heat tolerance** may be subject to **adaptation** or **acclimat(izat)ion.** Synonym: **heat endurance.**
Note: In the OED the words tolerance and endurance are almost synonymous. From a physiological point of view a distinction is sometimes made between **heat tolerance** and **heat endurance**, the former term is sometimes used in a more general sense and includes all forms of tolerance, while the latter is sometimes used in a more specific sense as in tolerance with time during a sustained stress, e.g., exercise endurance.

Heat transfer: Process of **heat flow** [W], i.e., the rate at which heat energy is transferred from one part of an organism to another especially between body core and **shell**. In this case the **heat transfer** is a combination of conduction and convection. A more frequently investigated topic of thermal physiology is **heat transfer** between an organism and its **environment**, by conduction, convection, radiation, evaporation, or a combination of these. Net transfer from the organism to the **environment** is **heat loss**, and from the ambiance into the organism is **heat gain.** → **Body heat balance equation.**

Heat transfer coefficient: A parameter (h) [$W \cdot m^{-2} \cdot °C^{-1}$] which determines the amount of **heat flux (*H*)** due to a temperature difference (ΔT): $H = h \cdot \Delta T$. H may be defined for conduction, convection, radiation (or the combination of these processes) and for evaporation (see below).

Heat transfer coefficient, combined nonevaporative (h_{comb}): The ratio of total **heat transfer** per unit area by radiation, convection, and conduction to the temperature difference between the surface and **operative temperature** of the **environment**.

$$h_{comb} = h_r + h_c + h_k \; [W \cdot m^{-2} \cdot °C^{-1}]$$

Heat transfer coefficient, conductive (h_k): The net **heat transfer** by conduction per unit area between a surface and a solid or stationary fluidic medium in contact with the surface per unit temperature difference (ΔT) between the surface and the substance with which it is in contact.

$$h_k = K \cdot \Delta T^{-1} \; [W \cdot m^{-2} \cdot °C^{-1}]$$

Heat transfer coefficient, convective (h_c): The net **heat transfer** per unit area between a surface and a moving fluidic medium per unit temperature difference (ΔT) between the surface and the medium.

$$h_c = C \cdot \Delta T^{-1} \; [W \cdot m^{-2} \cdot °C^{-1}]$$

Heat transfer coefficient, evaporative (h_e): The net **heat transfer** per unit vapor pressure gradient caused by the evaporation of water from a unit area of wet surface or by the condensation of water vapor on a unit area of body surface. The driving force is the **vapor pressure** gradient from P_{ws} (on the surface) to P_{wa} (of the ambient gas). Thus

$$h_e = E(P_{ws} - P_{wa})^{-1} \cdot [W \cdot m^{-2} \cdot Pa^{-1}] \text{ or } [W \cdot m^{-2} \cdot Torr^{-1}].$$

In terms of the **latent heat of vaporization** (λ or LHV) of water, the gas constant for water vapor (R_w), the mean temperature (T) of the medium in °K and the **mass transfer coefficient (h_D)**

$$h_e = h_D \cdot \lambda \cdot R_w^{-1} \cdot T^{-1}$$

Note: In most physiological applications the **vapor pressure** gradient instead of the concentration gradient can be considered as the driving potential for the evaporative process since the temperature difference between the evaporating surface and the ambient air is small in relation to the average temperature of the surface-water vapor medium.

Heat transfer coefficient, radiative: The net rate of **heat transfer** per unit area by the exchange of thermal radiation between two surfaces, per unit temperature difference between the surfaces. [$W \cdot m^{-2} \cdot °C^{-1}$]

Heat transfer coefficient, radiative (linear) (h_r): According to the **Stefan-Boltzmann Law**, the exchange of radiation between two black surfaces at temperatures T_1 and T_2 [°K] is proportional to σT^4, where σ is the Stefan-Boltzmann constant. When the ratio $(T_1 - T_2)/T$ is small, where $T = (T_1 + T_2)/2, \sigma(T_1{}^4 - T_2{}^4) \approx 4\sigma T^3 \cdot (T_1 + T_2)$ and the term $4\sigma T^3$ can be treated as a linear **heat transfer coefficient**. [$W \cdot m^{-2} \cdot °C^{-1}$]

Heliothermy: The regulation of the body temperature of an **ectothermic** animal by behavioral adjustments of its exposure to solar radiation. (Gk. *helios*-the sun; *therme*-heat)

Hemihidrotic response: Suppression of **thermal sweating**, due to the **skin pressure effect**, if one half of the body is affected.

Hemispherical emissivity. → Emissivity, hemispherical.

Heterothermy: The pattern of **temperature regulation** in a **tachymetabolic** species in which the variation in **core temperature**, either **nychthemerally** or seasonally, exceeds that which defines **homeothermy**. (Gk. *hetero*-different; *therme*-heat)
Note: This is an arbitrary term in two senses: i) because *hetero* = a difference from (i.e., a difference between two) rather than a wide range, and ii) because the distinction that is being made between thermostable and rather less thermally stable species depends on an arbitrary division. →: **1. poikilothermy** (diversified temperatures) although etymologically satisfactory has already been given a more restricted meaning. **2. stenothermy** (narrow temperature range) and **eurythermy** (wide temperature range) would have suited the circumstance well, but these terms are already in use to describe animals that are able to adjust to narrow ranges and wide ranges respectively, of **ambient temperature**.

Heterothermy, local: The pattern of temperature in those parts of the body which comprises the **thermal shell** of **homeotherms**.

Hibernation: The state of winter (sometimes late fall or early spring) lethargy with a reduction in body temperature and **metabolism** of some animals that are **homeothermic temperature regulators** when active. (L. *hibernare*- to pass the winter)
Note: Body temperature is **regulated** in the state of **hibernation**, however, with **set-point** differing from that in the state of **cenothermy (euthermy).**

Hidromeiosis: The swelling of keratinized layers of the skin, due to prolonged exposure to water or sweat, which blocks sweat ducts and reduces sweating rate. (Gk. *hidros*-sweat; *meiosis*-decrease)

Homeostasis: General term characterizing the relative constancy of physico-chemical properties of the internal environment of an organism as being maintained by **regulation**. (Gk. *homoio*-similar, resembling; *stasis*-standing)

Homeothermy: The pattern of **temperature regulation** in a **tachymetabolic** species in which the cyclic variation in **core temperature**, either **nychthemerally** or seasonally, is maintained within arbitrarily defined limits despite much larger variations in **ambient temperature**, i.e., **homeotherms** regulate their body temperature within a narrow range. (Gk. *homoio*-similar, resembling; *therme*-heat) Synonym: **homoiothermy.**
Note: A number of **homeothermic** species may temporarily enter states in which their set-range of body **temperature regulation** is not definable or much lower than during their normal state of **homeothermy** (→ **heterothermy, hibernation, torpor**).

Homoiothermy. → Homeothermy.

Humidity, absolute (γ): Mass of water vapor in air per unit volume of air/water vapor mixture. [$kg \cdot m^{-3}$]

Humidity, relative (ϕ): The ratio of the mol fraction of water vapor present in a volume of air to the mol fraction present in saturated air, both at the same temperature and pressure; in thermal physiology, the ratio of the **saturated vapor pressure** at the **dew point temperature** ($P_{s,\ dp}$) of the enclosure to the **saturated vapor pressure** at its **dry bulb temperature** ($P_{s,\ db}$) [ND]. When the **relative humidity** is expressed as a percentage, the symbol is RH.

Hyperpnea, thermal. → Thermal hyperpnea.

Hyperthermia: The condition of a **temperature regulator** when **core temperature** is above its range specified for the normal active state of the species. (Gk.

hyper-over; *therme*-heat)
Note: **Hyperthermia** may be *regulated* (e.g., in **fever** or during dehydration**)** or may be *forced* if **total heat production** exceeds the capacity for **heat loss**.

Hyperthermia, induced: The state of **hyperthermia** produced purposefully by increase in heat load and/or inactivation of heat dissipation by physical and/or pharmacological means.
Note: **Induced hyperthermia** is used in a few specific conditions as a therapeutical adjuvant. It may also be locally induced (e.g., by microwave irradiation or organ perfusion). **Induced hyperthermia** should be distinguished from **fever** induced by administration of **pyrogens**, which is an obsolete technique to produce elevations of body temperature in medicine for therapeutical purposes.

Hyperthermia, malignant: A pharmacogenetic myopathy characterized by a rapid rise in body temperature in genetically susceptible subjects during anaesthesia (triggering agents: halothane, succinyl choline, etc.). **Malignant Hyperthermia** stems from impairment (genetically originated) in the sarcoplasmic reticulum, leading to alteration in handling of the excess cytosolic Ca^{++}, skeletal muscle rigidity and spasticity and, in-turn, increased **heat production**. The often fatal **hyperthermia** is the result of heat production in skeletal muscle and supported by the limitations of active heat dissipation during anaesthesia. It is complicated by sympathetic activation, excessive lactate production and acidosis, muscle rigidity, myoglobinaemia, and disturbances of cellular permeability.

Hypothermia: The condition of a **temperature regulator** when **core temperature** is below its range specified for the normal active state of the species. (Gk. *hypo*-beneath; *therme*-heat).
Note: **Hypothermia** may be *regulated* (e.g., **Torpor**, **Hibernation**) or may be *forced* if **heat loss** exceeds the capacity for **total heat production**.

Hypothermia, accidental: The condition of a **temperature regulator** following an accidental or deliberate decrease in **core temperature** below its range specified for the normal active state of the species. The condition usually occurs in a cold environment and is associated with an acute problem, but without primary pathology of the **temperature regulating** system.

Hypothermia, induced: The state of **hypothermia** produced purposefully by increasing **heat loss** from the body and/or inactivation of heat conservation and heat production by physical and/or pharmacological means.
Note: **Induced hypothermia** is employed in surgery to reduce the oxygen demand of tissues that are particularly sensitive to circulatory arrest.

Indirect calorimetry. → Calorimetry, indirect.

Induced Hypothermia.→ Hypothermia, induced.

Infrared. → Radiant energy.
Note: The infrared wave band is radiant heat.

Insensible heat loss. → Heat loss, insensible.

Insensible perspiration: The mass of water passing through the skin by diffusion per unit area in unit time. [$kg \cdot m^{-2} \cdot s^{-1}$] Synonym: **passive cutaneous water vapor exchange. Insensible perspiration** represents a fraction of the **insensible water loss**.
Note: Hitherto, rates of **insensible perspiration** and of **sweating** have been expressed most commonly in [$g \cdot m^{-2} \cdot h^{-1}$], but this does not conform with SI conventions. The most convenient SI term appears to be [$mg \cdot m^{-2} \cdot s^{-1}$] ($3.6\ g \cdot m^{-2} \cdot h^{-1} = 1\ mg \cdot m^{-2} \cdot s^{-1}$).

Insensible water loss: The sum of the water lost by diffusion through the skin and water lost in breathing, and excluding any water excreted (e.g., in sweat, urine, feces). [$kg \cdot s^{-1}$] or [$kg \cdot m^{-2} \cdot s^{-1}$] Loss of water as vapor implies loss of heat according to the **latent heat of vaporization** of water.
Note: Restricting the term *water* to its state as a fluid is obsolete, as is the designation of water loss as *insensible* if it is lost as water vapor. However, the term **insensible water loss** is still used, mainly in the literature pertaining to farm animals. In thermal physiology its use should be avoided because of possible confusion with **insensible heat loss;** *passive evaporative water loss* should be considered as an alternative term.

Insulation. → Thermal resistance.

Interleukin-1 (IL-1): Heat labile proteins produced by immune cells (e.g., mononuclear phagocytes) when activated by microorganisms or their products. There are two forms of IL-1 (α and β). The production of **interleukin-1 (IL-1)** is caused by infection, injury and trauma. It (as well as other **cytokines**) produces the **acute phase response**. IL-1 is considered an important **endogenous pyrogen,** as are interleukin-6 (IL-6), **tumor necrosis factor α (TNF α)**, and some other **cytokines**.

Interthreshold zone. → **Thermoeffector threshold zone.**

Irradiance (E): The **radiant flow** incident on or passing through unit area of a surface. [$W \cdot m^{-2}$]

Katathermometer: An instrument which measures the **heat flow** from a surface to a cooler environment.

Latent heat of fusion: The quantity of heat absorbed, or released, in the reversible change of state, melting or freezing, of unit mass of solid or liquid, without change of temperature. [$J \cdot g^{-1}$]
Note: The melting of 1 g of ice to water at 0°C absorbs 333.15 J.

Latent heat of vaporization (λ or LHV): The quantity of heat absorbed (or released) by a volatile substance (fluid) per unit mass in the process of its reversible change of state by evaporation (or condensation) under isobaric and isothermal equilibrium conditions. [$J \cdot g^{-1}$]
Note: For water: $\lambda = 2490.9 - 2.34\ T$, with T = temperature of water in °C, e.g., 1 g of water, when changing from fluid to vapor at T = 34°C, absorbs 2411.3 J.

Least observed metabolic rate. → **Metabolic rate, least observed.**

Lower critical temperature. → **Critical temperature, lower.**

Lower temperature survival limit. → **Temperature survival limit, lower.**

Malignant hyperthermia. → **Hyperthermia, malignant.**

Mass diffusivity. → **Diffusivity, mass.**

Mass transfer coefficient (diffusion) (h_D): The rate of mass transfer ($\dot{m}$) from a vaporizing liquid (usually water) to a moving gas (usually air) in contact with it, per unit area (A) of the liquid surface and per unit difference between the vapor density (saturated) at the surface (p_{ws}) and the vapor density of the ambient gas (p_{wa}), expressed in the equation

$$h_D = \dot{m} \cdot A^{-1}\ (p_{ws} - p_{wa})^{-1}\ [m \cdot s^{-1}]$$

→ **heat transfer coefficient, evaporative; mass transfer rate.**

Mass transfer, convective: The transport by convection of one component of a nonreactive mixture (usually air-water) across an interface caused by a concentration gradient often accompanied by a transformation of phase and by a simultaneous transfer of heat.

Mass transfer rate ($\dot{m}$): The rate of transfer of mass. [$kg \cdot s^{-1}$]

Maximum metabolic rate. → **Metabolic rate, maximum.**

Maximum oxygen consumption. → **Oxygen consumption, maximum.**

Mean body temperature. → **Temperature, mean body.**

Mean radiant temperature. → **Temperature, mean radiant.**

Mean skin temperature. → **Temperature, mean skin.**

Menopausal hot flush (flash): An abrupt heat dissipation response, provoked or unprovoked, occurring in hypoestrogenic women following the decline of ovarian function. The response typically lasts about 5 minutes and consists of peripheral vasodilation, **sweating** and reports of intense warmth.

Met: An assigned unit of measurement to designate "sitting-resting" metabolic rate of man.

$$1\ met = 58.15\ W \cdot m^{-2} = 50\ kcal \cdot h^{-1} \cdot m^{-2}$$

It is an empirical unit of measurement to express the **metabolic rate *(M* or *MR)*** of a man whose clothing has an insulative value of 1 clo when he is sitting at rest in comfortable indoor surroundings (21°C).

Metabolic body size: The function of an animal's body size to which **standard metabolic rate *(SMR)*** (or **basal metabolic rate *(BMR))*** is directly proportional. Synonym: **metabolically effective body mass**.
Note: **Metabolic body size** is often calculated using body mass raised to a power (W^b) as in the expression $M = aW^b$. That the **resting metabolic rate *(RMR)*** of adult animals (both **tachymetabolic** and **bradymetabolic**) changes in proportion to the 3/4 power of body mass is an empirically established fact, and the use of

$W^{3/4}$ as the **metabolic body size** permits comparisons to be made between the metabolic levels of different animals. When $W^{2/3}$ is used, this implies proportionality of **metabolic body size** to the animal's surface area (→ **surface rule**). The relation between **metabolic rate** ***(M*** or ***MR)*** and body size ($M = aW^{3/4}$) is a particular case of the general allometric equation ($y = ax^b$) which says that plotting a biological variable, y, against another biological variable, x, after logarithmic transformation (i.e., $\log y = \log a + b \cdot \log x$) will result in a straight line with slope b. Ref: von Bertalanffy, L., *Helgoländer Wiss. Meeresuntersuch.* 9: 5, 1964.

Metabolic energy production. → Metabolic energy transformation.

Metabolic energy transformation (*M*). → Metabolic rate.

Metabolic heat production (*H*): Rate of transformation of chemical energy into heat in an organism, usually expressed in terms of unit area of the total body surface (→ **total body area**). *H* is equal to $M - (W)$ in the **body heat balance equation**. $[W \cdot m^{-2}]$, $[W \cdot kg^{-1}]$ or [W]

Note: During **positive work rate** (+*W*) or in the absence of work ($W = 0$) **metabolic heat production** ($H = M - (+W)$), i.e. **positive work rate** subtracted from **the rate of metabolic energy transformation (=metabolic rate)**, equals **total heat production**. When work is being done on the body by an external source (**negative work**), **total heat production** is the sum of **metabolic rate *(M*** or ***MR)*** (which is equal to metabolic heat production in this condition) and the heat liberated within the body due to **negative work** *(M – (– W))*.

Metabolic level: The **metabolic heat production** measured under standard conditions (→ **metabolic rate, standard *(SMR)***) during a 24-h period divided by the **metabolic body size**. $[kJ \cdot kg^{-3/4} \cdot (24\ h)^{-1}]$*

Note: *$1\ kJ \cdot kg^{-3/4} \cdot (24\ h)^{-1} = 0.2388\ kcal \cdot kg^{-3/4} \cdot (24\ h)^{-1}$. **Metabolic levels** are approximately constant within phylogenetic groups but may vary between groups. For example, mammalian and avian species (**tachymetabolism**) have higher **metabolic levels** than other species (**bradymetabolism**), while the **metabolic levels** of birds are apparently higher than those of mammals, and those of prototherian (monotreme) and metatherian (marsupial) mammals are lower than those of eutherian (placental) mammals.
(Poczopko, 1971). Ref: Poczopko, P., *Acta Theriologica* 16: 1, 1971.

Metabolic rate (*M* or *MR*): = **metabolic energy transformation**. [W], $[W \cdot m^{-2}]$, $[W \cdot m^{-3}]$, $[W \cdot kg^{-1}]$, $[W \cdot kg^{-3/4}]$ The rate of transformation of chemical energy into heat and mechanical work by aerobic and anaerobic metabolic activities within an organism, usually expressed in terms of unit area of the total body surface, i.e., as a **heat flux**. The quantity ***M*** in the **body heat balance equation**.

Note: **Metabolic energy transformation** may not all result from aerobic metabolic activities and may therefore exceed that indicated by the rate of oxygen consumption. Part of the **metabolic energy transformation** may be used to do work on an external system, and therefore the rate of heat production may be less than the **metabolic energy transformation**. Terms in the **body heat balance equation** are often expressed as quantities of **energy** per unit surface area and per unit time $[W \cdot m^{-2}]$, because heat exchange is a function of area. **Metabolic rate *(M*** or ***MR)*** is given as the total energy production in the organism in unit time [W] or often as the energy production per unit mass of tissue in unit time $[W \cdot kg^{-1}]$. For comparison of **metabolic rates** of animals of different body sizes, **metabolic rate *(M*** or ***MR)*** is usually related to (body mass)$^{3/4}$ (→ **metabolic body size**).

Metabolic rate, basal (*BMR*): metabolic energy transformation calculated from measurements of heat production or oxygen consumption in an organism in a rested, awake, fasting* sufficiently long to be in post-absorptive state, and **thermoneutral zone** (a particular case of **standard metabolic rate *(SMR)***).[W], $[W \cdot m^{-2}]$, $[W \cdot m^{-3}]$, $[W \cdot kg^{-1}]$, $[W \cdot kg^{-3/4}]$

Note: In these conditions, when the amount of work being done on an external system is negligible, the rate of heat production is equal to the rate of **metabolism** (**metabolic energy production**).* The period of fasting needs to be specified as this may be for days in large animals, and for much shorter periods for very small mammals and birds.

Metabolic rate, lowest observed (*LOMR*): The lowest observed rate of **metabolism** during specified periods of minimum activity. [W], $[W \cdot m^{-2}]$, $[W \cdot kg^{-1}]$, $[W \cdot kg^{-3/4}]$ → **metabolic rate, minimum observed (*MOMR*)**. The rationale and objective of **lowest observed metabolic rate (*LOMR*)** and **minimum observed metabolic rate *(MOMR)*** are identical: to measure the **metabolic rates** of small and wild animals during periods of minimal activity as the nearest that can be made to a measurement of a **standard metabolic rate *(SMR)***.

Note: There are small but significant differences in technique: **Minimum observed metabolic rate *(MOMR)*** is the average **metabolic rate *(M* or *MR)*** during periods of minimum activity; **lowest observed metabolic rate (*LOMR*)** is the *lowest* recorded **metabolic rate *(M* or *MR)*** during periods of minimum activity. Such brief low values may be influenced by physical characteristics of the system of measurement. *Note:* **lowest observed metabolic rate (*LOMR*)** may be lower than **basal metabolic rate *(BMR)*** (e.g., during some stages of sleep).

Metabolic rate, maximum (*MMR*): The highest **metabolic rate *(M* or *MR)*** during a specified period of work compatible with sustained aerobic metabolism (i.e., when there is no progressive accumulation of lactic acid in the blood). [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$],[$W \cdot kg^{-3/4}$]
Note: There may be some confusion between **maximum** and **peak metabolic rates *(PMR)***. Both terms indicate maximum rates. The distinction is in usage: **maximum** relates to work, **peak** relates to cold exposure. The terms should also be distinguished from **maximum oxygen consumption.**

Metabolic rate, minimum observed (*MOMR*): Averaged **metabolic rate** during specified periods of minimum activity. [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$], [$W \cdot kg^{-3/4}$]
Note: The **metabolic rate *(M or MR)*** of small animals in particular, but also of larger wild animals, cannot be measured under basal or other standard conditions (→ **metabolic rate, basal *(BMR)***, and **metabolic rate, standard *(SMR)***). A practical solution to the problem is to measure **metabolic rate *(M* or *MR)*** continuously and accept the average **metabolic rate *(M* or *MR)*** during periods of minimum activity as the best possible estimate of **standard metabolic rate *(SMR).***

Metabolic rate, peak (*PMR*): The highest **metabolic rate *(M* or *MR)*** that can be induced in a resting animal by any cold environment. [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$], [$W \cdot kg^{-3/4}$] Synonym: **summit metabolic rate.** → **Metabolic rate, maximum *(MMR)***.
Note: Although summit metabolic rate (*SMR*) is now an accepted term, **peak metabolic rate (*PMR*)** is preferable because the abbreviation *SMR* is indistinguishable from that for **standard metabolic rate (*SMR*).**

Metabolic rate, resting (*RMR*): The **metabolic rate *(M* or *MR)*** of an animal that is resting in a thermoneutral environment but not in the postabsorptive state. [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$], [$W \cdot kg^{-3/4}$]
Note: A particular case of **standard metabolic rate *(SMR)*** used when the subject cannot be brought to a fasting condition, e.g., ruminant animals. The period of food deprivation should be stated.

Metabolic rate, standard (*SMR*): metabolic energy transformation calculated from measurements of heat production or oxygen consumption in an organism under specified standard conditions*. [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$], [$W \cdot kg^{-3/4}$]
Note: The conditions are usually such that the amount of work being done on an external system is negligible. The rate of heat production is then an acceptable index of the rate of metabolism. * The specified standard conditions are usually that the organism is rested (or as near to rested as is possible), fasting (if possible), awake, and in a thermoneutral environment. The extent to which standard conditions can be achieved varies with species. → **Metabolic rate, minimum observed *(MOMR)*.**

Metabolic rate, summit. → **Metabolic rate, peak.**

Metabolic scope. → **Scope, metabolic.**

Metabolically effective body mass: → **metabolic body size** (preferred synonym).
Note: The term **metabolically effective body mass** may be wrongly understood to be that part of the body mass which is metabolically active in contrast to a part that is metabolically inert. Its use should be avoided.

Metabolism. → **Metabolism, energy.** (Gk. *metabole*-change)
Note: **Metabolism** is a general term which relates to chemical and physical changes occurring in living organisms. In thermal physiology **metabolism** invariably relates to the transformation of chemical energy into work and heat. In other divisions of physiology the term is used in relation to other changes in state of chemical energy (e.g., from storage compounds to readily available compounds, including the energy transferring polyphosphates, and *vice versa*), or to turnover of material between different states (e.g., calcium salts from ionized to solid, and *vice versa*).

Metabolism, anaerobic: Transformation of matter and energy without uptake of oxygen.

Metabolism, energy: The sum of the chemical changes in living matter in which energy is transformed. (Gk. *metabole*-change) → **metabolism**.

Microwave: Part of the electromagnetic spectrum with wavelength from 1 to 100 mm. **Microwaves** are absorbed by metal and water and thus permit deep heating of aqueous or metallic bodies exposed to them (→ **radiant energy**).

Minimum observed metabolic rate. → **Metabolic rate, minimum observed.**

Natural convection. → **Convective heat transfer.**

Negative work. → **Work rate, negative.**

Neuroleptic malignant syndrome: The development of severe muscle rigidity, elevated **core temperature**, and a disturbance of mental status associated with the use of neuroleptic medication.

Nocturnal: Occurring during the nighttime, as distinct from daytime. (L. *nocturnus* adj < *nox*-night) Antonym: **diurnal.**

Nonevaporative heat loss. → **Heat loss, nonevaporative.**

Non-freezing cold injury (NFCI): Tissue damage resulting from prolonged exposure to **ambient temperatures** between 15°C down to –0.5°C. In **NFCI** the normal thermoregulatory responses of the injured body are disturbed. All types of tissue may be damaged by sustained cooling, but the most serious effects occur in the nerves and blood vessels. Antonym: **Freezing cold injury (FCI).**

Nongenetic adaptation. → **Adaptation, phenotypic.**

Nonshivering thermogenesis. → **Thermogenesis, nonshivering.**

Nonthermal sweating. → **Sweating, nonthermal.**

Normothermy. → **Cenothermy.**

Nychthemeral: Relating to an exact period of 24 h. (Gk. *nux*-night; *hemera*-day).

Nychthemeron: A period of 24 h, consisting of a day and a night (SOED).

Obligatory nonshivering thermogenesis. → **Thermogenesis, nonshivering (obligatory).**

Operative temperature. → **Temperature, operative.**

Optimal body temperature range: The range of body temperatures in which a species carries out its normal daily activity.
Note: This "ecological optimum" integrates internal and external forces acting on a species; it applies mostly to **ectotherms**.

Oxygen consumption, maximum ($\dot{V}O_{2max}$): The maximum rate at which an organism can take up oxygen. [$ml \cdot s^{-1}$], conventionally [$ml \cdot min^{-1}$], [$l \cdot min^{-1}$]
Note: Determination of this parameter requires very high motivation of the subject and can probably be done only on humans. Criteria used to show that a human subject has reached the $\dot{V}O_{2max}$ although not as yet agreed upon, include an indication of no further increase in oxygen uptake during further increase in work load.

P 32000 polypeptide. → **UCP1**

Panting, thermal. → **Thermal panting.**

Partitional calorimetry. → **Calorimetry, partitional.**

Passive cutaneous water exchange: The passage through the skin in either direction of water down an osmotic gradient per unit area in unit time. [$kg \cdot m^{-2} \cdot s^{-1}$], also [$mg \cdot m^{-2} \cdot s^{-1}$]
Note: **Passive cutaneous water exchange** occurs only when the skin is covered with water or an aqueous solution.

Passive cutaneous water vapor exchange: The passage through the skin in either direction of water vapor down a water **vapor pressure** gradient per unit area in unit time. [$kg \cdot m^{-2} \cdot s^{-1}$], also [$mg \cdot m^{-2} \cdot s^{-1}$]. Synonym: **insensible perspiration**.

Passive temperature lability. → **Temperature lability, passive.**

Peak metabolic rate. → **Metabolic rate, peak.**

Phenotypic adaptation. → **Adaptation, phenotypic.**

Physical temperature regulation. → **Temperature regulation, physical.**

Physical thermoregulation. → **Temperature regulation, physical.**

Physiological temperature regulation. → **Temperature regulation, physiological.**

Physiological thermoregulation. → **Temperature regulation, physiological.**

Piloerection: Involuntary bristling of hairs or ruffling of feathers; in thermal physiology an autonomic **thermoeffector** response often associated with behavioral (e.g., postural) adjustments.

Poikilothermy: Large variability of body temperature as a function of **ambient temperature** in organisms without effective **autonomic temperature regulation**. As a rule, **bradymetabolism** implies **poikilothermy** with only temporary exceptions in some species (e.g., active warming-up of insects before flight). Synonym: **Temperature conformer**. **Tachymetabolism** excludes **poikilothermy**, except in pathological conditions (impairment of **temperature regulation**), but permits **heterothermy** or **torpor** to occur in a number of species. (Gk. *poikilos*-changeful, diversified; *therme*-heat) Antonym: **homeothermy.**
Note: For **ectothermic** organisms without effective **thermoregulatory behavior**, **poikilothermy** is synonymous with **temperature conformity**. *Poikilo-* is inconsistent with other uses of this root in biology; it should, perhaps, be *poecilo-* or *pecilo-;* cf. poeciloblast, poecilocyte (OED).

Polypnea, thermal. → **Thermal polypnea.**

Positive work. → **Work, positive.**

Postprandial (excess) heat production. → **Heat production (excess), postprandial.**

Potohidrotic response: The instantaneous intense sweating appearing when **hyperthermic** dehydrated humans drink. (Gk. *poto*-drink; *hidro*-sweat).

Power (W): Physically power [W] is **energy** per time unit. In the case of mechanical energy per time unit it is called mechanical power or, particularly in thermal, sports and occupational physiology, **work rate** and attributed the letter *W*.
Note: W, e.g., in the **heat balance equation**, is work rate in [W] and not work in [Ws = J]. In the case of thermal energy (heat) per time unit it is called heat flow and attributed the letter *H* [W].
Note: All quantities in the so-called **body heat balance equation** constitute power (either heat **flow** or **work rate**). For convenience, they may be expressed in [W], in [$W \cdot m^{-2}$], in [$W \cdot m^{-3}$], or in [$W \cdot kg^{-1}$].

Preferred ambient temperature: The range of **ambient temperature**, associated with specified **radiation intensity**, humidity, and air movement, from which an unrestrained human or animal does not seek to move to a warmer or colder environment. [°C]

Preferred body temperature: The range of **core temperature** within which an **ectothermic** animal seeks to maintain itself by behavioral means. [°C]

Pressure (P): The force exerted per unit area. [Pa, bar, Torr] A liquid or gas enclosed in a container will exert an uniform pressure on its walls, if the influence of gravitational forces is excluded or of little importance as in case of gases.
Note: The SI-derived unit of pressure is the Pascal (Pa), which is defined as a newton per square meter ($N{\cdot}m^{-2}$). An alternate SI-derived unit of pressure is the bar (bar) defined as 10^5 Pa. The unit of pressure currently approved by the International Commission of the IUPS for Respiratory Physiology is the Pascal [Pa] which is synonymous with the pressure unit mmHg (an obsolescent unit). One Torr is equal to 1.33322 millibars or 133.322 Pa.

Pressure, atmospheric (P): The pressure due to the weight of the atmosphere as indicated by a barometer. **Standard atmospheric pressure** is the pressure 101.325 kilopascals (kPa) (or the weight of a 760 mm column of mercury at 0°C with density 13.5951×10^3 $kg \cdot m^{-3}$ under standard gravity of $9.80665\ m \cdot s^{-2}$) and is equivalent to 1,013.25 millibars or to 760 Torr.

Pressure, water vapor (P_w): The pressure exerted by water vapor. If water vapor is confined over its liquid so that the vapor comes into equilibrium with the liquid, and the ambient temperature T_a of the medium is held constant, the **vapor pressure** approaches a maximum value called the **saturated vapor pressure** ($P_{s,Ta}$) or (P_{sa}). The term **vapor pressure (water)** is always synonymous with a **saturated vapor pressure** at a temperature T. [Pa, millibar, Torr]
Note: The water vapor pressure (→ **vapor pressure (water)**) of an enclosure may be calculated from the observed **wet bulb** and **dry bulb temperatures** and the atmospheric pressure, by using standard steam or mete-

orological tables and formulas (Ref: Chambers, A.B., A psychrometric chart for physiological research, *J. Appl. Physiol.* 29: 406–412, 1970). The water vapor pressure in an enclosure is equal to the **saturated vapor pressure** at its **dew-point temperature** ($P_{s,Tdp}$) or to the product of the **relative humidity** (N) and the **saturated vapor pressure** at its **dry bulb temperature** ($NP_{s,Tdp}$).

Projected area. → **Area, projected.**

Pyrexia: The condition of being **febrile**.
Note: **Pyrogen:** The generic term for any substance whether exogenous or endogenous that causes **fever** when introduced into or released in the body. (Gk. *pur*-fire; <*gen*-become).

Pyrogen, bacterial: Any **pyrogen** derived from bacteria.
Note: All **endotoxins** are **bacterial pyrogens**.

Pyrogens, endogenous: Heat labile proteins, and lipids that cause **fever**. Their production is often stimulated by **exogenous pyrogens** (microorganisms and their products, e.g., antigens), but also by injury, trauma and stress. The best identified **endogenous pyrogen** is **interleukin-1**β (IL-1β). It is thought that this **cytokine** induces **fever** via the production of another **cytokine**, IL-6. Other **endogenous pyrogens** include interferon-α and **tumor necrosis factor-**α. The final common pathway for **cytokine**-mediated **fever** is generally thought to be the production of prostaglandins of the E series in or near the anterior hypothalamus.

Pyrogen, exogenous: A substance which, when entering the inner environment of a multicellular organism (host) will cause **fever.** Stimulation of the production and/or release of **endogenous pyrogens** is, at least in most instances, the humoral effect from which **fever** ultimately results.
Note: The most potent **exogenous pyrogens** are heat-stable lipopolysaccharides intrinsic to the cell walls of gram-negative bacteria (→ **endotoxin**). Many **exogenous pyrogens** of different molecular composition exist; they comprise compounds intrinsic to bacteria, viruses, fungi, mycobacteria, and some protozoa, as well as foreign proteins and some steroids.

Q_{10}: The ratio of the rate of a physiological process at a particular temperature to the rate at a temperature 10°C lower, when the logarithm of the rate is an approximately linear function of temperature (Ref. Precht, H., J. Christophersen, H. Hensel, & W. Larcher. *Temperature and Life,* Berlin-Heidelberg-New York, Springer, 1973, p. 17 ff.).

Radiance (L_e): Radiance at a surface element (dA) of a source or receiver is the **radiant intensity** (dI) from direction θ divided by the orthogonal projection of this surface element (dA ·cosθ) on a plane perpendicular to the direction θ. θ is the angle between the normal to the element (dA) of the source or receiver and the direction of the observation. $[W \cdot sr^{-1} \cdot m^{-2}]$

Radiance thermal ($L_{e,th}$): radiance due to thermal radiation. $[W \cdot sr^{-1} \cdot m^{-2}]$

Radiant absorptance, total (α): The ratio of total **radiant flux** absorbed by a body to the total incident flux.

Radiant emittance. → **Radiant exitance.**

Radiant energy (Q): Energy travelling in the form of electromagnetic waves. [J]
Note: This term should be distinguished from the **radiant heat exchange** (***R***) of the environment with the body. That part of the electromagnetic spectrum of significance in thermal physiology is divided for convenience into the wavebands:

Ultraviolet	0.25–0.38 μm
Visible	0.38–0.78 μm
Infrared	0.78–100 μm
Microwave	1–100 mm

Radiant energy, spectral (Q_λ): The **radiant energy** per unit wave length interval at wavelength λ. $[J \cdot nm^{-1}]$

Radiant exitance (M_e): The **radiant flux** leaving an element of a surface. This quantity includes radiation emitted, reflected, and transmitted by the surface.

$$M_e = d\phi_e/dA = \int L_e \cdot \cos\theta \cdot d\Omega [W \cdot m^{-2}]$$

Note: The name **radiant emittance** previously given to this quantity is abandoned because it has given rise to confusion. Thus, the term **emittance** is used to designate either the flux leaving a surface whatever the origin (emitted, reflected, or transmitted), or the flux emitted by a surface (originating in the surface), or a quantity without dimensions similar to **emissivity** but applicable only to a specimen.

Radiant exitance, self ($M_{e,s}$): The **radiant flux** emitted by a surface. The flux considered does not include reflected or transmitted flux. [$W \cdot m^{-2}$]

Radiant exitance, thermal ($M_{e,th}$): The **radiant flux** emitted as thermal radiation by a surface.
Note: In the case of a **full radiator**, the **radiance** (**L_e**) is uniform in all directions. In consequence, when the solid angle is measured in steradians, the **radiant exitance** has the numerical value $M_e = 4\pi L_e$.

Radiant field, effective. → Radiant flux, effective.

Radiant flow (ϕ): The amount of **radiant energy** per unit of time. [W]

Radiant flow spectral (ϕ_λ): The **radiant flow** per unit wavelength interval at wavelength λ. [$W \cdot nm^{-1}$]

Radiant flux ($d\phi/dA$): The **radiant flow** per unit area. [$W \cdot m^{-2}$]
Note: The **radiant flux** emitted by a surface is the **thermal radiant exitance.** The **radiant flux** incident on or passing through an area is the **irradiance.**

Radiant flux, effective (H_r): The net **radiant flux** exchanged with all enclosing surfaces and with any intense directional sources and sinks for exchange of radiant heat by a human or human-shaped object whose surface temperature is hypothetically at **ambient air temperature**. [$W \cdot m^{-2}$]
Note: If the same object, with surface temperature at **ambient air temperature**, is assumed to exchange radiant heat at a given **effective radiant flux** with a hypothetical black surface enclosure of corresponding wall temperature, then this condition defines the **effective radiant field** transferring the amount of heat per unit time and per unit surface of the object which is quantified by the **effective radiant flux**. In this sense, **effective radiant field** and **effective radiant flux** are synonymous terms.

Radiant heat exchange (*R*): The net rate of heat exchange by radiation between an organism and its environment, usually expressed in terms of unit area of the total body surface, i.e., as a **heat flux**. The quantity (*R*) in the **body heat balance equation** where (–*R*) = **heat gain** and (+*R*) = heat loss. [W] or [$W \cdot m^{-2}$]

Radiant intensity (I): The **radiant flow** proceeding from a source per unit solid angle in the direction considered. [$W \cdot sr^{-1}$]

Radiant intensity, spectral (I_λ): The **radiant intensity** per unit wave length interval. [$W \cdot sr^{-1} \cdot nm^{-1}$]

Radiation reflectance. → Reflectance, radiation.

Radiation shape factor (F_{ij}): A dimensionless quantity expressing the fraction of the diffuse energy emitted by a surface (or a source), denoted by the subscript i, that is received by another surface, denoted by the subscript j, visible by it and in known geometric relation with it. Synonym: **radiation view factor.**

Radiation transmittance. → Transmittance, radiation.

Radiation view factor. → Radiation shape factor.

Radiative heat transfer coefficient. → Heat transfer coefficient, radiative.

Radiative (linear) heat transfer coefficient. → Heat transfer coefficient, radiative (linear).

Radiator: An emitter of **radiant energy.**

Radiator, full: A **radiator** of uniform surface temperature whose **radiant exitance** in all parts of the spectrum is the maximum obtainable. The **emissivity** of a full radiator is unity for all wavelengths. Synonym: **blackbody.**

Radiator, graybody: A **radiator** whose **spectral emissivity** is less than unity, at least in the waveband for thermal radiation (3–30 μm), but is the same at all wavelengths.

Radiator, selective: A **radiator** with a **spectral emissivity** less than unity which varies with wavelength.
Note: Human and animal skins have high **emissivities** in the waveband 3–30 μm but not between 0.7 and 3 μm.

Reflectance, radiation (ρ): The ratio of the **radiant flux** reflected by a surface or medium to the incident flux.
Note: Measured values of **reflectance** depend upon the angles of incidence and view and the spectral character of the incident flux; these factors should be specified.

Regulation: The processes by which a biological system stabilizes variables, generally by information loops (negative feedback **control**). The regulated (controlled)

physiological variables can usually be described as a function of physical variables. In the case of changes of a regulated variable due to external or internal interference, the processes of **regulation** will alter certain bodily functions, the effectors in the regulatory process, which act to minimize the deviations of the regulated variable from its **set-point.**
Note: In thermal physiology, **core temperature** is often considered as the regulated variable in **homeothermic** species, because its changes are most effective in activating the **thermoeffectors** of heat production, heat conservation, or **heat loss** in such a way that deviations of **core temperature** are minimized. **Mean body temperature**, if representing the weighted contributions of **core** and **shell** temperatures to the entire thermal information, may be a better estimate of the regulated variable.

Relative humidity. → **Humidity, relative.**

Resistance, thermal. → **Thermal resistance.**

Respiratory evaporative heat loss *(REHL)*: Rate of heat dissipated by exhalation of air saturated with water vapor, [W], [W·m^{-2}], [W·m^{-3}], [W·kg^{-1}].
Note: **Respiratory evaporative heat loss *(REHL)*** comprises a passive (obligatory) fraction associated with normal breathing and, in many animals, a regulatory fraction which depends on the rate at which the water vapor dissipating respiratory surfaces are ventilated (e.g., during **thermal tachypnea**), and on surface temperature depending on **circulatory convection** (→ **convection, circulatory**) transferring heat to these surfaces. Net dissipation of evaporated water and, consequently, of heat with the exhaled air is possible only as long as the inhaled air is not saturated with water vapor at the temperature of the moist respiratory surfaces.

Resting metabolic rate. → **Metabolic rate, resting.**

Saliva spreading: The spreading of saliva on the body surface, often a deliberate (behavioral) **thermoeffector** action to cool the surface by evaporation. Sometimes inaccurately termed grooming.

Saturated vapor pressure. →**Pressure, water vapor.**

Scope, metabolic: Metabolic rate *(M or MR)* at **maximum oxygen consumption** divided by **least observed metabolic rate *(LOMR)***.

Second phase panting. → **Thermal hyperpnea.**

Selective brain cooling: Lowering of brain temperature, either locally or as a whole, below aortic (arterial blood) temperature. Cool venous blood returning from cephalic heat dissipating surfaces acts as a heat sink, either for brain tissue directly or for arterial blood supplying brain tissue. Special vascular arrangements, e.g., the ophthalmic or carotid *retia mirabilia*, support arterio-venous heat exchange underlying **selective brain cooling**. Its existence in many species has been proven, but the situation in humans is still debated.

Sensible heat loss. → **Heat loss, dry.**

Set-point: The value of a regulated variable which a healthy organism tends to stabilize by the processes of **regulation.** It is found in the condition when the effector activities tending to counteract alterations of the regulated variable are minimal. With thermal load present, the regulated variable, due to proportional control, does not stabilize at, but near the **set-point**. In **hyper-** or **hypothermia**, body temperature deviates substantially from the **set-point**, mostly because of insufficient effector capacity and thereby lack of stabilization. In biological systems, the apparent **set-points** of many regulated variables may change with time, either periodically or temporarily (e.g., **nychthemerally,** annually, with the ovulatory cycle, or in connection with other physiological events). In **temperature regulation** the **set-point** may change temporarily, due to interference with the regulations of nonthermal variables (e.g., in states of dehydration and starvation, etc.), or due to pathological, nonthermal influences (e.g., in **fever** or **anapyrexia**). Also, the processes of **acclimat(izat)ion** and **adaptation** may change the **set-point** of **temperature regulation**. **Hibernation** is a special condition in which the **set-point** differs distinctly from that existing in the same animal in the state of **cenothermy.** The change of **set-point** in these processes is thought to be due to changes in the thermal controller characteristics, particularly changes of thresholds (→ **thermoeffector threshold temperature**) and/or changes of **thermoeffector gain**, which obviously have neuronal correlates, too.
Note: The term set-point has evoked much confusion, as it has been used for different phenomena: (1) for **steady state** of body temperatures (which can be very different in the thermoregulatory system depending on environmental and internal conditions). (2) for a central reference signal (which obviously does not exist explicitly in the thermoregulatory system). (3) for **thermoeffector threshold zone** of (mean) body temperature, which is correct only in the non-acclimated and **afe-**

brile state. In **fever** (also in **acclimat(izat)ion** and other adaptational or periodical processes) the thermocontroller characteristics change (particularly effector threshold), and by this the **set-point**, which then does not fall into the **interthreshold zone**. With non-excessive additional thermal load, body temperature stabilizes near this **febrile set-point**.

Shape factor, radiation. → **Radiation shape factor.**

Shell, thermal: The skin and mucosal surfaces of the body engaged directly in heat exchange with the environment and, in addition, those tissues under these surfaces whose temperatures may deviate from **core temperature**, due to heat exchange with the environment and to changes in **circulatory convection** (→ **convection, circulatory)** of heat from the **core** to the heat exchanging surfaces. Antonym: **thermal core**.
Note: The temperature of the **shell** of **temperature regulators** depends on **ambient temperature**, **heat loss** to the environment, and on rate and geometry of blood flow to and from the skin.

Shivering: Involuntary tremor of skeletal muscles as a **thermoeffector** activity for increasing **metabolic heat production** (→ **thermogenesis, shivering**). Its electromyographically distinct pattern of motor unit discharges may be quantified as the integrated voltage (V) deflections per unit time (t): $\Sigma(\Delta V \cdot \Delta t) \cdot t^{-1} \cdot [V]$.(→ **thermoregulatory muscle tone**).

Sickness behavior: A group of signs or symptoms which accompany **cytokine**-producing events (e.g., infection), usually with the elevation of body temperature. The behaviours include, among others, loss of appetite, lethargy, depression and decreased motor activity, and are thought to be mediated by the action of **cytokines**, not necessarily those which mediate the rise in body temperature, as a result of the infection.

Skin pressure effect on sweating: The inhibition of **sweating** in the dermatomal area of skin when mechanical pressure is locally applied (→ **hemihidrotic response**).

Skin wettedness. → **Wettedness, skin.**

Solar radiation area. → **Area, solar radiation.**
Specific dynamic action. → **Specific dynamic effect.**

Specific dynamic effect: Temporary increase in **metabolic energy transformation** following food intake. Originally described as "spezifisch-dynamische Wirkung" by Rubner, the term "Wirkung" has been translated as "action" as well as "effect". The phenomenon is assumed to be related to the catabolism of food stuffs, particularly proteins. (Kleiber, M. *The Fire of life*, Huntington, N.Y., R.E. Krieger Publ. Co., 1976).
Note: The term is becoming obsolete, because it cannot be distinguished precisely from other factors that stimulate metabolic energy transformation in the hours following food intake and, with the inclusion of the **specific dynamic effect**, account for **postprandial (excess) heat production.** Synonyms: **specific dynamic action; diet-induced thermogenesis.**

Specific heat (c): The quantity of heat required to raise the temperature of unit mass of a substance by one degree Celsius. $[J \cdot kg^{-1} \cdot °C^{-1}]$
Note: For gases, it is necessary to specify whether the pressure (c_p) or the volume (c_v) is held constant during its determination. The **specific heat** of body tissue is usually taken to be 3.48 $kJ \cdot kg^{-1} \cdot °C^{-1}$ (i.e., 0.83 kcal $\cdot kg^{-1} \cdot °C^{-1}$). Ref: Schafer, E.A., *Textbook of Physiology*, London: Hodder & Stoughton, 1898, vol. I, p. 838.

Specific heat, volumetric: The product of the **density** ρ of a material and its **specific heat**. $[J \cdot °C^{-1} \cdot m^{-3}]$

Spectral emissivity. → **Emissivity, spectral.**

Spectral radiant energy. → **Radiant energy, spectral.**

Spectral radiant flow. → **Radiant flow, spectral.**

Standard atmospheric pressure. → **Pressure, atmospheric.**

Standard metabolic rate. → **Metabolic rate, standard.**

Steady state: The state of **body heat balance** in which there is no positive or negative **heat storage** when **heat gain** and **heat loss** between the body and the environment are equivalent. The body temperatures reached in a **steady state** depend on the extent of external or internal thermal load. If the **thermoeffector** capacities are exceeded due to excessive load or pathological processes, a steady state will not be reached, leading to **hypo-** or **hyperthermia**.

Stefan-Boltzmann law: The **thermal radiant exitance** of a **full radiator** is proportional to the fourth power of its absolute temperature, $M_{e,th} = \sigma T^4$. The currently recommended value of the Stefan-Boltzmann constant (σ) is 5.6696×10^{-8} [$W \cdot m^{-2} \cdot K^{-4}$].

Stenothermy: Descriptive of organisms, which occur naturally in a narrow range of environmental temperatures and which, singly or collectively, are intolerant of or accommodate ineffectually to wide changes in their thermal environment. (Gk. *stenos*-narrow; *therme*-heat) Antonym: **eurythermy.**

Storage of body heat (*S*): The rate of increase (+) or decrease (–) in the **heat content** [Ws = J] of the body caused by an imbalance between heat production **(metabolic heat transformation)** and **heat loss**, usually expressed in terms of unit area of total body surface **(→ Area, total body)**. The quantity ***S*** in the **body heat balance equation**. [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$] or [$W \cdot kg^{-1}$]:

Stress fever: A rise in body temperature due to exposure of a person or an animal to a psychological stressor. Synonym: **Stress hyperthermia.**

Stress hyperthermia. → Stress fever.

Sunstroke: An acute and dangerous reaction to heat exposure caused by a failure of the heat regulating mechanisms of the body. It is characterized by high **core temperature**, usually above 40.6°C, cessation of **thermal sweating**; headache, numbness, tingling and confusion prior to sudden delirium or coma, fast pulse, rapid respiratory rate and elevated blood pressure.

Surface area. → Area, total body, and area DuBois (for humans only).

Surface rule: A statement that the **basal metabolic rate *(BMR)*** is proportional to the 2/3 power of body mass.
Note: The rule is based on the proposition that **basal metabolic rate *(BMR)*** is related to surface area and that surface area varies with the 2/3 power of body mass. However, this is not experimentally verifiable, for when **basal metabolic rate *(BMR)*** is expressed per 2/3 power of body mass it increases systematically with body size (Kleiber, 1947). **Basal metabolic rate *(BMR)*** is more nearly proportional to the 3/4 power of body mass (→ **metabolic body size**). Ref: Kleiber, M., *Physiol. Rev.* 27: 411, 1947.

Sweating, nonthermal: A response of the sweat glands to a nonthermal stimulus.

Sweating, thermal: A response of the sweat glands to a thermal stimulus. Rate [$mg \cdot m^{-2} \cdot s^{-1}$]
Note: $1\ mg \cdot m^{-2} \cdot s^{-1} = 3.6\ g \cdot m^{-2} \cdot h^{-1}$.

Sweating topography, thermal: The sequence of the onset of **thermal sweating** and the differences in sweat rate observed between different skin regions.

Tachymetabolism: The high level of **basal metabolism** of birds and mammals relative to those of reptiles and other nonavian and nonmammalian animals of the same body mass and at the same tissue temperatures. (Gk. *takhus*-fast; *metabole*-change) Synonym: **warm-blooded**. Antonym: **bradymetabolism, cold-blooded.**
Note: This relatively high level of **basal metabolism** in mammals and birds is a precondition for the relative stability of **core temperature** during exposure to cold (**warm-blooded**) and of **endothermic homeothermy** and **heterothermy.**

Tachypnea, thermal. → Thermal tachypnea.

Temperature: A measure of the mean kinetic energy of the molecules in a volume.

Temperature, ambient (T_a): The average temperature of a gaseous or liquid environment (usually air or water) surrounding a body, as measured outside the thermal and hydrodynamic boundary layers that overlay the body. [°C] Synonym: **temperature, dry bulb** (in a gaseous environment).

Temperature coefficient: The ratio between the change in any temperature dependant activity and the defined temperature range within which this change occurs.

Temperature conformer: An organism, the **core temperature** of which varies as a proportional function of **ambient temperature**; an animal without effective **temperature regulation** by autonomic or behavioral means. Synonym: **poikilothermy.** Antonym: **temperature regulator.**

Temperature conformity: The thermal relation between the **environment** and an organism, the **core temperature** of which varies as a proportional function of **ambient temperature**, i.e., an absence of effective **temperature regulation** by autonomic or behavioral means.

Temperature, core: Ideally, the mean temperature of the **thermal core**. In practice it is represented by a specified **core temperature**, usually rectal or (in humans) sublingual temperature. More reliable in conditions of changing **core temperature** are esophageal (at the cardia) or aortic (arterial blood) temperature.
Note: Brain temperatures are **core temperatures**. They may differ regionally within the brain or from other **core temperatures** outside of the brain, due to **selective brain cooling**, which directly influences brain temperature, locally or as a whole, in a number of species.

Temperature, deep body. → **Temperature, core** (preferred synonym).

Temperature dependence: The influence of the local temperature upon the rate of all molecular transformations and thereby upon practically all cellular and physiological processes. → $\mathbf{Q_{10}}$.

Temperature, dew-point ($\mathbf{T_{dp}}$): The temperature at which condensation first occurs when an air-water vapor mixture is cooled at constant pressure. [°C]

Temperature, dry bulb ($\mathbf{T_{db}}$): The temperature of a gas or mixture of gases indicated by a thermometer shielded from radiation. [°C] Synonym: **temperature, ambient**.

Temperature, effective ($\mathbf{T_{eff}}$): An arbitrary index which combines in a single value the effect of temperature, humidity, and air movement on the sensation of warmth or cold felt by human subjects. The numerical value is that of the temperature of "still" air saturated with water vapor which would induce an identical sensation. [°C]

Temperature, globe ($\mathbf{T_g}$): The temperature of a blackened hollow sphere of thin copper (usually 0.15 m diameter) as measured by a thermometer at its center; $\mathbf{T_g}$ approximately equals **temperature, operative**. [°C]

Temperature lability, controlled: An expression of the extent of the daily and seasonal variations in the level at which **core temperature** is being regulated. Synonym: **thermolability, controlled.**
Temperature lability, passive: An expression of the extent to which **core temperature** fluctuates passively (i.e., without the recruitment of **thermoeffector** activities) when either the rate of heat production or of heat exchange with the **environment** is varied. Synonym: **thermolability, passive.**

Temperature, mean body ($\mathbf{\overline{T}_b}$): (1) Ideally, the sum of the products of the **heat capacities** ($c_i \cdot m_i$) and temperature (T_i) of all tissues of the body divided by the total heat capacity of the organism:

$$\overline{T}_b = \Sigma(c_i \cdot m_i \cdot T_i)/\Sigma(c_i \cdot m_i).$$

(2) The total temperature signal generated by all **thermosensors** distributed in the **core** and **shell**. (2) should be different from (1). For discussion, see Minard, D., In: *Physiological and Behavioral Temperatuve Regulation*, edited by J.D. Hardy, A.P. Gagge, & J.A.J. Stolwijk, Springfield, I11., Thomas, 1970, p. 345.
Mean body temperature often is estimated approximately from measurements of a representative **core temperature** (T_c) and **mean skin temperature** ($\overline{T}_{sk}$) according to:

$$\overline{T}_b = a_l \cdot T_c + a_2 \cdot \overline{T}_{sk}, \text{ with } a_l + a_2 = 1,$$

in which the factors a_l and a_2 represent the empirically determined contributions of **thermal core and shell** to **mean body temperature**.

Temperature, mean radiant ($\mathbf{\overline{T}_r}$): The temperature of an imaginary isothermal "black" enclosure in which a solid body or occupant would exchange the same amount of heat by radiation as in the actual nonuniform enclosure. [°C]

Temperature, mean skin ($\mathbf{\overline{T}_{sk}}$): The sum of the products of the area of each regional surface element (A_i) and its mean temperature (T_i) divided by the **total body** (surface) **area.**

$$\overline{T}_{sk} = \Sigma(A_i \cdot T_i)/A_b \text{ [°C]}$$

Note: **Mean skin temperature** can be used as a physical variable in the calculation of heat balance or of heat content of the body. It is, however, not necessarily a good estimate of what might be sensed as a **mean skin temperature** according to the integrated neural input of the cutaneous **thermoreceptors,** because different surface regions may differ in their importance as **thermosensor** sites.
Temperature, operative ($\mathbf{T_o}$): The temperature of a uniform (isothermal) "black" enclosure in which a solid body or occupant would exchange the same amount of heat by radiation and convection as in the actual nonuniform environment. [°C]

Temperature receptor. → **Thermoreceptor.**

Temperature regulation: The maintenance of the temperature or temperatures of a body within a restricted range under conditions involving variable internal and/or external heat loads. Biologically, the existence of body **temperature regulation** to some extent by autonomic or behavioral means. Antonym: **temperature conformity.**

Temperature regulation, autonomic: The regulation of body temperature by autonomic (i.e., involuntary) **thermoeffector** responses to heat and cold which modify the rates of heat production and **heat loss** (i.e., by **sweating, thermal tachypnea, shivering, nonshivering thermogenesis**, and adjustments of **circulatory convection** of heat to the surfaces of the body). (Gk. *autos*-self; *nomos*-law, i.e., self-governing, SOED).
Note: In this definition the term *autonomic* is used in its more general sense and does not imply that all responses are controlled by the *Autonomic Nervous System* (sympathetic and parasympathetic efferents). Autonomic **temperature regulation** is frequently described as **physiological temperature regulation**, a term which should be used for both autonomic and behavioral thermoregulatory processes.

Temperature regulation, behavioral: Any coordinated movement of an organism ultimately tending to establish a thermal **environment** that represents a preferred condition for heat exchange (**heat gain**, **heat loss**, or **heat balance**) of the organism with its environment. The distinction between **thermoregulatory behavior** and **thermotropism** is ill-defined. A plant may exhibit **thermotropism** but is not considered to be thermoregulating. Some aquatic unicellular organisms move to a **preferred ambient temperature**, however, whether this is **thermotropism** or **thermoregulatory behavior** may be disputed. For these reasons the term is usually restricted in thermal physiology to patterns of behavior controlled by a nervous system. The complex patterns of somato-motor activities that serve as behavioral **thermoeffector** responses to heat and cold of **temperature regulators** in modifying their conditions of heat exchange with the **environment**, involve a wide variety of performances (e.g., moving to a different thermal ambiance, changes in posture, wetting of body surfaces, change of microclimate by nest building, parental behavior, huddling) and, in humans, also include voluntary exercise and cultural achievements (clothing, housing, air-conditioning etc.). In **endothermic temperature regulators**, the reduced demand for **autonomic temperature regulation** is a potential result of **behavioral temperature regulation** which, however, competes with other, nonthermal, behavioral drives (e.g., search for food).
Note: **Behavioral temperature regulation** is characterized as **operant**, if it is acquired in an experimental condition only after training guided by an experimenter. Otherwise, it is defined as **natural**, but this may also involve learning. In humans the distinction between natural and operant **behavioral temperature regulation** becomes arbitrary in many instances.

Temperature regulation, chemical (obsolete)**:** Body **temperature regulation** involving changes in heat production.
Note: This can be due to: 1. voluntary muscle movements; 2. involuntary muscle movements (e.g., shivering); 3. nonshivering thermogenesis; 4. increase or decrease in **basal metabolic rate *(BMR)***.

Temperature regulation, physical (obsolete)**:** Body **temperature regulation** involving control of the rate of heat flow into or out of an organism.
Note: The responses involved in such regulation consist of those autonomic and behavioral responses that vary the **thermal conductance** of peripheral tissues, but not of those behavioral responses which involve alteration of the local environment. For example: 1. changes in peripheral vasomotor tone; 2. **piloerection**; 3. evaporation of water from skin (following **sweating**, **saliva spreading**, **wallowing**) and from respiratory tract surfaces; 4. changes in body conformation.

Temperature regulation, physiological: 1) Both autonomic and **behavioral temperature regulation** (preferred). 2) Obsolete synonym for **autonomic temperature regulation**.
Note: Traditionally, mammalian thermoregulatory physiology has been concerned with those responses to heat or cold which do not depend on behavior. These reponses are autonomic (SOED self-governing; Gk. *autos*-self, independently; *nomos*-law). Autonomic responses are generally referred to as physiological responses, but behavioral responses are also physiological (Physiology = the science of the normal functions and phenomena of living things, SOED). Thus, physiological thermoregulatory responses properly consist of both **autonomic** and **behavioral** responses.

Temperature regulator: An organism which regulates its body temperature to some extent by **autonomic** and/or **behavioral** processes. Antonym: **temperature**

conformer.
Note: **Tachymetabolism** is the property of **endothermic** temperature regulators in which **core temperature** appears as the controlled variable, with arbitrarily defined degrees of thermostability (**homeothermy, heterothermy**). **Bradymetabolism** does not exclude that such species may be **ectothermic** temperature regulators, although mainly by means of **behavioral temperature regulation**, because **thermoeffectors** of **autonomic temperature regulation** are vestigial or absent.

Temperature responsive. → **Thermoresponsive.**

Temperature sensitive. → **Thermosensitive.**

Temperature sensor. → **Thermosensor.**

Temperature survival limit, lower: The environmental temperature below which thermal balance cannot be maintained for a long period and animals become progressively **hypothermic**. At this temperature → **basal metabolic rate (*BMR*)** can be measured.

Temperature survival limit, upper: The environmental temperature above which thermal balance cannot be maintained for a long period and animals become progressively **hyperthermic**.

Temperature, tolerated ambient range. → **Tolerated ambient temperature range.**

Temperature, tympanic (T_{ty}): The temperature of the tympanic membrane.

Temperature, wet bulb (T_{wb}): The thermodynamic wet bulb temperature of a sample of air is the lowest temperature to which it can be cooled by evaporating water adiabatically. This measurement is compared to that read by an ordinary thermometer, or **dry bulb** thermometer, to estimate the ambient humidity. [°C]
Note: The term is usually applied to the temperature recorded by an aspirated thermometer covered with a wet sleeve that is approximately equal to the thermodynamic wet bulb temperature when the bulb is shielded from radiation.
Thermal comfort: Subjective indifference to the thermal environment.

Thermal comfort, zone of: The range of **ambient temperatures**, associated with specified **mean radiant temperature**, humidity, and air movement, within which a human in specified clothing expresses indifference to the thermal environment for an indefinite period. [°C]

Thermal conductance (k): The rate at which heat is transferred between unit area of two parallel surfaces in a medium when unit temperature difference is maintained between them, or the rate of **heat transfer** during steady state when a temperature difference of 1 °C is maintained across a layer of tissue, either expressed per unit area [$W \cdot m^{-2} \cdot °C^{-1}$] or in absolute terms [$W \cdot °C^{-1}$].
Note: This term relates to the total **heat transfer** (no matter which physical processes are involved) down a temperature gradient from any tissue to its immediate environment, e.g., from a tissue to circulating blood, as well as from the body **core** through peripheral tissues to the body surface (due to conductive as well as convective processes). In practice **tissue thermal conductance** of living tissues within the organism is not amenable to direct measurement. Calculated values are usually based on several assumptions, e.g., mean tissue temperature, mean blood temperature, and the surface areas of blood vessel walls.

Thermal conductivity (λ): A property of a material defined by the flow of heat by conduction through unit thickness of the material per unit area and per unit temperature difference maintained at right angles to the direction of heat flow. [$W \cdot m^{-1} \cdot °C^{-1}$]

Thermal contact coefficient. → **Thermal inertia for radiant heat.**

Thermal core. → **Core, thermal.**

Thermal diffusivity. → **Diffusivity, thermal.**

Thermal expansion coefficient of volume (β): The change in volume (V) at constant pressure of a substance (solid or fluid) per unit volume, per degree change in temperature (T; degree Kelvin).
$\beta = V^{-1} \cdot dV/dT$ (gases only) [K^{-1}]

Thermal hyperpnea: An increase in tidal volume associated with an increase in alveolar ventilation occurring during severe heat stress which has caused a large rise in **core temperature**. In animals capable of **thermal panting** the phase of **thermal hyperpnea** with its slower, deeper breathing is also named **second phase panting**, since it is usually preceded by a phase of typical panting (rapid, shallow breathing). (Gk. *hyper*-above, over; *pnoia*-breath)

Thermal indifference, zone of: The range of **ambient temperatures**, associated with specified water vapor pressure, air velocity, and radiant exchange, within which 80% of active people do not complain of the thermal environment. [°C] Cf. **thermoneutral zone.**

Thermal inertia for radiant heat ($\sqrt{kpc}$): One of the properties of a material which determines the rate of increase of surface temperature during an exposure to **irradiance** (E). For nonpenetrating radiation incident upon a semi-infinite solid with uniform properties, the value of the thermal inertia for the surface can be determined in appropriate units by $\sqrt{kpc} = 2\pi^{-1/2} \cdot t^{1/2} \cdot E \cdot \Delta T^{-1}$ in which ΔT is the rise in surface temperature at time, t.

Thermal insulation. → Thermal resistance.

Thermal insulation, clothing (I_{cl}): The intrinsic insulation of a clothing assembly. The effective insulation of clothing is ($I_{cl} + I_a$) where I_a is the reciprocal of the thermal conductance of the ambient environment. ($I_{cl} + I_a$) is usually measured as the temperature gradient from the surface of a heated man-sized manikin to the ambient air divided by the heat production per unit area of manikin surface. [$°C \cdot m^2 \cdot W^{-1}$] The value is sometimes expressed in **clo** units.

Thermal panting: Increased **respiratory evaporative heat loss *(REHL)*** due to increased respiratory minute volume.
Note: **Thermal panting** in animals can occur both with a closed and open mouth.

Thermal polypnea. → Thermal tachypnea.
Note: Although **polypnea** is more commonly used, **tachypnea** is etymologically more correct.

Thermal radiance. → Radiance, thermal.

Thermal radiant exitance. → Radiant exitance, thermal.

Thermal resistance (R): The reciprocal of **thermal conductance**. [$°C \cdot m^{-2} \cdot W^{-1}$] or [$°C \cdot W^{-1}$] Synonym: **thermal insulation**.

Thermal shell. → Shell, thermal.

Thermal strain: In **temperature regulators**: 1. Any deviation of body temperature induced by sustained **thermal stress** that cannot be fully compensated by **temperature regulation**; 2. Any activation of **thermoeffector** activities in response to **thermal stress** that cause sustained changes in the state of other, nonthermal, regulatory systems.

Thermal stress: Any change in the thermal relation between a **temperature regulator** and its **environment** which, if uncompensated by **temperature regulation**, would result in **hyper-** or **hypothermia**.

Thermal sweating. → Sweating, thermal.

Thermal tachypnea: A rapid respiratory frequency accompanied by an increase in respiratory minute volume and, commonly, a decrease in tidal volume, in response to a thermoregulatory need to dissipate heat. (Gk. *takhus*-swift; *pnoia*-breath) Synonym: **thermal polypnea**.

Thermoeffector: An organ system and its action, respectively, that affect **heat balance** in a *controlled* manner as part of the processes of **temperature regulation**.
Note: A multitude of **thermoeffectors** is involved in both **autonomic** and **behavioral temperature regulation**.

Thermoeffector gain: The derivative of the **thermoeffector** output with respect to body temperature deviation from the **set-point**.
*Note:*The gain may change due to **fever**, **adaptation** and other processes. In combination with **thermoeffector threshold temperature**, **thermoeffector gain** is an important characteristic of **thermoeffectors**.

Thermoeffector threshold: The level of activity of a potential **thermoeffector** that is transgressed when it becomes actively involved in **temperature regulation**.
Note: For some of the thermoeffectors, thresholds can be precisely determined, e.g., as the level of **basal metabolic rate *(BMR)*** or **resting metabolic rate *(RMR)*** of a **tachymetabolic** animal above which **metabolic heat production *(H)*** will increase in response to a sufficiently strong cold exposure. The thresholds of other **thermoeffectors** are arbitrarily defined, or agreed upon by convention, because basal or resting levels are difficult to define, e.g., in case of **circulatory convection** of heat to the skin and the underlying cutaneous vasomotor tone.

Thermoeffector threshold temperature: Describes the level of a specified body temperature (e.g., **core**

temperature or **mean body temperature**) the transgression of which in one direction, either upward or downward, will activate a certain **thermoeffector**. As a rule, the threshold **core temperature** determined for a given effector will be a function of skin temperature, and vice versa; similar interdependencies exist with and among the threshold temperatures determined for specified **thermosensor** regions in the body **core** (e.g., hypothalamus, spinal cord). Evaluation of **mean body temperature** threshold values tries to account for the entire thermal input from the body. Specified threshold temperatures for certain **thermoeffectors** may change during the processes of **fever**, **acclimat(izat)ion** and **adaptation**. Threshold temperature and **thermoeffector gain** are the dominant parameters describing the **thermoeffector** output as a function of body temperature, thus, they constitute essential characteristics of the thermal controller.

Thermoeffector threshold zone (Interthreshold zone): The temperature range between two threshold (body) temperatures, for activation of any **thermoeffector** responses, particularly of **metabolic heat production (*H*)** and of **evaporative heat loss** when no thermal load is present. This special **steady-state** may be called **set-point**. **Thermoeffector threshold zone** should be distinguished from **thermoneutral zone (TNZ).**

Thermogenesis, diet-induced: Increase of **obligatory nonshivering thermogenesis** occurring especially in rodents when transferred from standard food to a highly palatable *cafeteria diet*, of which the animals consume more but dissipate part of the surplus caloric intake by enhanced heat production. The **brown adipose tissue (BAT)** is considered as the main effector organ of **diet-induced thermogenesis**.
Note: The relationship between **postprandial (excess) heat production** and diet-induced thermogenesis is not presently clarified.

Thermogenesis, nonshivering (NST): Heat production due to **metabolic energy transformation** by processes that do not involve contractions of skeletal muscles, i.e., tone, microvibrations, tremor (→ **shivering**), or tonic or voluntary contractions. In thermal physiology this term is conventionally used to indicate **thermoregulatory** (cold-induced) **nonshivering thermogenesis (NST).** [W], [$W \cdot m^{-2}$], [$W \cdot kg^{-1}$]
Note: While all organs contribute to **obligatory nonshivering thermogenesis** according to their rates of **resting metabolism**, the principal effector organ responsible for the short-term or adaptive activation of **nonshivering thermogenesis (NST)**, observed particularly in small mammals, is the **brown adipose tissue (BAT).**

Thermogenesis, nonshivering (obligatory) (NST(O)): That component of **nonshivering thermogenesis (NST)** (i.e., heat production unrelated to the contractions of voluntary muscles) that is independent of short-term changes in **ambient temperature (T_a)**.
Note: **NST(O)** corresponds to **basal metabolic rate *(BMR)*** or **standard metabolic rate *(SMR)***. Although **NST(O)** is unaffected by short-term exposure to cold, it may be changed by processes of **acclimat(izat)ion** to sustained cold or heat stress or feeding conditions.

Thermogenesis, nonshivering, (thermoregulatory) (NST(T)): The increase in **nonshivering thermogenesis (NST)** in response to acute cold exposure. The principal effector organ is the **brown adipose tissue (BAT).** which may adaptively increase its capacity for heat production in the course of **acclimat(izat)ion** and **adaptation** to cold stress.
Note: The term **nonshivering thermogenesis (NST)** usually refers to NST(T).

Thermogenesis, shivering: An increase in the rate of heat production during cold exposure due to increased contractile activity of skeletal muscles not involving voluntary movements and external work. [W], [$W \cdot kg^{-1}$], [$W \cdot m^{-2}$] or [$W \cdot m^{-3}$]
Note: **Shivering thermogenesis** progresses, as its intensity increases, from **thermoregulatory muscle tone**, to micro-vibrations, to clonic contractions of both flexor and extensor muscles. All **shivering thermogenesis** is blocked by curare.

Thermogenin. → P 32000 Polypeptide.

Thermography, infra-red: The recording of the temperature distribution of a body from the **infra-red radiation** emitted by the surface.

Thermolability, controlled. → Temperature lability, controlled.
Thermolability, passive. → Temperature lability, passive.

Thermoneutral zone (TNZ): The range of **ambient temperature** at which **temperature regulation** is achieved only by control of **sensible heat loss**, i.e., without regulatory changes in **metabolic heat production (*H*)** or **evaporative heat loss**. **The thermoneutral**

zone (TNZ) will therefore be different when insulation, posture or **basal metabolic rate *(BMR)*** vary. The term **thermoneutral zone (TNZ)** does not apply to **ectotherms**. The **thermoneutral zone (TNZ)** should be distinguished from **thermoeffector threshold zone**.

Thermopreferendum: The thermal conditions that an individual organism or a species selects for its ambient environment in natural or experimental circumstances.

Thermoreactive: Descriptive of neural elements whose activity changes with the temperature of a remote region of the body, due to synaptic input from this region.
Note: A central nervous neuron may be both **thermoreactive** and **thermoresponsive (thermosensitive)**.

Thermoreceptor: Thermosensitive neural element for which both its afferent function and its response characteristics are electrophysiologically identified (→ **thermosensor**). Synonym: **temperature receptor**.
Note: **Thermoreceptors** have been unequivocally identified, so far, only in the skin and mucous surfaces as **cold receptors, warm receptors**, and infrared receptors.

Thermoregulation. → Temperature regulation.

Thermoregulatory behavior. → Temperature regulation, behavioral.

Thermoregulatory behavior, natural: → Temperature regulation, behavioral.

Thermoregulatory behavior, operant. → Temperature regulation, behavioral.

Thermoregulatory conditioned reflex: The physiological (**autonomic and behavioral**) responses of an organism to changes in its thermal environment, which can also be elicited by a conditioned stimulus.

Thermoregulatory muscle tone: The increase in the electrical activity of the skeletal musculature of a resting **tachymetabolic temperature regulator** during moderate cooling. During more intensive cooling, **thermoregulatory muscle tone** will be superimposed by microvibrations and eventually shivering tremor. The corresponding electrical activities can be determined qualitatively and quantitatively by means of electromyographical recording (→ **shivering**).

Thermoregulatory nonshivering thermogenesis. → Nonshivering thermogenesis (thermoregulatory).

Thermoresponsive: Neural element which changes its activity in response to changes of its own temperature. Synonyms: **temperature responsive, thermosensitive**.
Note: In comparison to the more general term **temperature dependence**, neuronal **thermoresponsiveness** implies at least the possibility of generation or modulation of information by temperature, either non-specific or as a specific temperature signal. The synonymous term **thermosensitive** implies the specificity of the thermoresponsive neural element as a temperature signal generator.

Thermosensitive: Descriptive of **thermoresponsive** neural structures with the implication that the neural elements involved provide specific temperature signals. Synonym: **temperature sensitive**.

Thermosensor: Neural element or circuitry of neural elements for which it is established by psychophysical criteria or analysis of **thermoeffector** responses or changes of **core temperature** that they transduce temperature in such a way that thermal sensation is elicited and/or **temperature regulation** is adequately stimulated.
Note: Thermosensors may not (yet) be accessible to electrophysiological identification, but their function is equivalent to that of **thermoreceptors** which are electrophysiologically identified thermosensors.

Thermotolerance: A rapid, short acting molecular process associated with the synthesis of several families of **heat shock proteins (HSP)** of different molecular weights elicited as a result of acute short sublethal heat injury. It is thought to protect cells from noxious stimuli as well as to accelerate their repair. It is also defined as **heat shock response (HSR)**. The time course of **heat shock proteins (HSP)** vary in different cells but, on the average, **heat shock proteins (HSP)** in the intact body seem to operate several hours following the stress and retains its activity for a few days. The response is not heat-specific and can be elicited subsequent to subjection to several other stressors (e.g., ischemia, some chemicals, etc.). Synonym: **heat shock response (HSR).**

Thermotropism: The turning or movement of a plant or animal in response to a temperature stimulus. (Gk. *therme*-heat; *trope*-turn)

Thigmothermy: The dependence of the **core temperature** of an **ectothermic** animal on the conductive exchange of heat with its immediate environment, e.g., water, air, soil. (Gk. *thigma*-touch; *therme*-heat)

Threshold temperature. → **Thermoeffector threshold temperature.**

Threshold, thermoeffector. → **Thermoeffector threshold.**

Tissue thermal conductance. → **Thermal conductance, tissue.**

Tolerated ambient temperature range: The range of **ambient temperature** (**T_a**) within which the body **core temperature** can be kept, by means of **autonomic thermoregulatory** processes, within certain limits typical for the species or the individual under consideration. [°C]

Torpor: A state of inactivity and reduced responsiveness to stimuli (e.g., during **hibernation, hypothermia**, or **estivation**).

Total body area (A_b). → **Area, total body.**

Total environment: All environmental factors that exert an influence on an organism and to which an organism must be adequately adapted in order to survive (i.e., competitors for food sources and predators as well as the many components of the physical environment and the climate).

Total heat production: The rate of transformation of chemical energy into heat in an organism (**metabolic heat production** (***H***)) plus any heat flow liberated within the body resulting from work done on the organism by an external force (**negative work rate**). [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], [$W \cdot kg^{-1}$]
Note: During **positive work** and when no work is being done on or by the organism, **total heat production** equals **metabolic heat production (*H*).**

Total radiant absorptance. → **Radiant absorptance, total.**

Transmittance, radiation (τ): The ratio of the **radiant energy** transmitted through a body to the total radiation incident on it.

Tumor necrosis factor-α (TNF-α): Heat labile proteins produced by immune cells (e.g., mononuclear phagocytes) when activated by microorganisms or their products. The production of **tumor necrosis factor (TNF-α)** is caused by infection, injury and trauma. It (as well as other **cytokines**) produces the **acute phase response**. **Tumor necrosis factor-α (TNF-α)** is considered an important endogenous pyrogen, as are **interleukin-1 (IL-1)**, interleukin-6 (IL-6), and some other **cytokines**.

UCP1: Specialized protein with a subunit M_r 32000 of the mitochondrial inner membrane of **brown adipose tissue (BAT)**; collapses the electro-chemical proton gradient generated by respiration and thus, prevents ATP synthesis; the amount of this mitochondrial component is increased when **brown adipose tissue (BAT)** is in a recruited state. Synonym: **thermogenin, uncoupling protein, P 32000 polypeptide**.

UCP2, UCP3: Proteins of similar amino acid sequence to **UCP1,** but found in tissues other than **brown adipose tissue (BAT)**, discussed as being involved in thermogenesis

Ultraviolet. → **Radiant energy.**

Uncoupling protein. → **P 32000 Polypeptide.**

Upper critical temperature. → **Critical temperature, upper.**

Upper temperature survival limit. → **Temperature survival limit, upper.**

Useful work accomplished. → **Work, positive.**

Vapor pressure (water). → **Pressure, water vapor.**

Volume, thermal expansion coefficient of. → **Thermal expansion coefficient of volume.**

Volumetric specific heat. → **Specific heat, volumetric.**

Wallowing: The thermoregulatory increase in evaporative heat loss by spreading an aqueous fluid (e.g., water, mud, urine) on the body surface.

Warm-blooded: The thermal state of an animal that maintains its **core temperature** considerably higher than that of the environment when subjected to a low **ambient temperature (T_a)**. Synonym: **tachymetabolic** (preferred). Antonym: **cold-blooded.**

Note: This maintained temperature gradient between the organism and its environment is dependent on the relatively high rate of **metabolic heat production (*H*)** (**tachymetabolism**) of warm-blooded animals compared with the low rate of heat production (**bradymetabolism**) of **cold-blooded** animals. Thus, the terms **tachymetabolic** and **bradymetabolic** are preferred to the terms **warm-blooded** and **cold-blooded** because the first pair of terms relates to a more basic physiological distinction and because the second pair of terms has been used with various meanings not all of which are consistent with the definitions given here. **Warm-blooded** is not a synonym of **homeothermic**, because the definition of **warm-blooded** does not specify the degree of temperature stability consistent with **homeothermy**: the **core temperatures** of some **warm-blooded** animals vary considerably either **nychthemerally** or seasonally.

Warm receptor. → Thermoreceptor.

Water loss, insensible. → Insensible water loss.

Wet bulb temperature. → Temperature, wet bulb.

Wetted area. → Area, wetted.

Wettedness, skin (w): The fraction of the **total body area (A_b)** that is covered by sweat (the **wetted area (A_w)**), i.e., A_w/A_b.
Note: For man the total skin area would usually be taken to be the **DuBois area** (A_D).

Window emissivity. → Emissivity, window.

Work efficiency (η): Work done on an external system per unit of energy expended by an organism in the performance of that work (i.e., total energy expended by an organism during the performance of work less that of **basal metabolism**). [%]

Work rate, negative (–*W*): The **rate** of work **(→ power)** done on an organism by an external force. The quantity (–W) in the **body heat balance equation**. [[W], $W \cdot m^{-2}$], [$W \cdot m^{-3}$], or [$W \cdot kg^{-1}$] Antonym: **work rate, positive**.

Work rate, positive (+*W*): The rate of work **(→ power)** done by an organism on an external system. The quantity (+*W*) in the **body heat balance equation**. [W], [$W \cdot m^{-2}$], [$W \cdot m^{-3}$], or [$W \cdot kg^{-1}$] Synonym: mechanical energy, **work production, useful work accomplished**. Antonym: **workrate, negative**.

Work production. → Work rate, positive.

Zone of thermal comfort. → Thermal comfort, zone of.

Zone of thermal indifference. → Thermal indifference, zone of.

Zone of thermoneutrality. → Thermoneutral zone.

APPENDIX 1. Système Internationale (SI) Units Used in the Glossary

	Quantity	Symbol for Quantity	SI Units	Abbreviations
Basic	electric current	I	ampere	A
	temperature	T	degree Kelvin	K
	mass	m	kilogram	kg
	length	l	meter	m
	time	*t*	second	s
Supplementary	plane angle	θ	radian	rad
	solid angle	Ω	steradian	sr
Derived	temperature	T	degree Celsius (0 °C = 273.15 K)	°C
	energy	E	joule ($kg \cdot m^2 \cdot s^{-2}$)	J
	force	F	newton ($J \cdot m^{-1}$)	N
	electric potential difference	V	volt ($J \cdot A^{-1} \cdot s^{-1}$)	V
	power	W	watt ($J \cdot s^{-1}$)	W
	pressure	P	pascal ($kg \cdot m^{-1} \cdot s^{-2}$) (= $N \cdot m^{-2}$) or bar (= 105 Pa)	Pa bar
			or torr (= 133.3 Pa)	Torr

APPENDIX 2. Symbols Used in the Glossary

Symbol or Abbreviation	Term	SI Units (Abbreviations) (ND = No Dimensions)
A_b	area, total body	m^2
A_D	area, DuBois	m^2
A_p	area, projected	m^2
A_r	area, effective radiating	m^2
A_s	area, solar radiation	m^2
A_w	area, wetted	m^2
BMR	metabolic rate, basal	W, $W \cdot m^{-2}$, , $W \cdot m^{-3}$, $W \cdot kg^{-1}$, $W \cdot kg^{-3/4}$
C	convective heat transfer	W, $W \cdot m^{-2}$, $W \cdot m^{-3}$, $W \cdot kg^{-1}$
CEHL	cutaneous evaporative heat loss	W, $W \cdot m^{-2}$, $W \cdot m^{-3}$, $W \cdot kg^{-1}$
D	diffusivity, mass	$m^2 \cdot s^{-1}$
E	irradiance	$W \cdot m^{-2}$
E	evaporative heat transfer	W, $W \cdot m^{-2}$, $W \cdot m^{-3}$, $W \cdot kg^{-1}$
F	radiation shape factor	ND
H	body height	m
H	heat flow	W, $W \cdot m^{-2}$, $W \cdot m^{-3}$, $W \cdot kg^{-1}$
HP	metabolic heat production	W, $W \cdot m^{-2}$,,$W \cdot m^{-3}$, $W \cdot kg^{-1}$, $W \cdot kg^{-3/4}$

APPENDIX 2. Symbols Used in the Glossary

H_r	radiant flux, effective	$W \cdot m^{-2}$
I	radiant intensity	$W \cdot sr^{-1}$
I_λ	radiant intensity, spectral	$W \cdot sr^{-1} \cdot nm^{-1}$
I_{cl}	thermal insulation, clothing	$m^2 \cdot °C \cdot W^{-1}$
K	conductive heat transfer	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}$
k	thermal conductance	$W \cdot m^{-2} \cdot °C^{-1}, W \cdot °C^{-1}$
L_e	radiance	$W \cdot sr^{-1} \cdot m^{-2}$
$L_{e,th}$	radiance, thermal	$W \cdot sr^{-1} \cdot m^{-2}$
LOMR	metabolic rate, lowest observed	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$
M_e	radiant exitance	$W \cdot m^{-2}$
$M_{e,s}$	radiant exitance, self	$W \cdot m^{-2}$
$M_{e,th}$	radiant exitance, thermal	$W \cdot m^{-2}$
M, *MR*	metabolic rate (metabolic energy transformation)	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$
MMR	metabolic rate, maximum	$W, W \cdot m^{-2}, W \cdot kg^{-1}, W \cdot kg^{-3/4}, W \cdot m^{-3}$
MOMR	metabolic rate, minimum observed	$W, W \cdot m^{-2}, W \cdot kg^{-1}, W \cdot kg^{-3/4}, W \cdot m^{-3}$
NST	thermogenesis, nonshivering	$W, W \cdot m^{-2}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$, $W \cdot m–^3$
NST(O)	thermogenesis, nonshivering (obligatory)	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$
NST(T)	thermogenesis, nonshivering (thermoregulatory)	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$
P	pressure	Pa, bar, Torr
$P_{s,T}$	pressure, vapor (saturated) at temperature T	Pa, bar, Torr
P_w	pressure, water vapor	Pa, bar, Torr
PMR	metabolic rate, peak	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$
Q	radiant energy	J
Q_λ	radiant energy, spectral	$J \cdot nm^{-1}$
R_w	gas constant (water vapor)	$3.47\ m^3 \cdot Torr \cdot kg^{-1} \cdot K^{-1}$
R	thermal resistance	$°C \cdot m^2 \cdot W^{-1}, °C \cdot W^{-1}$
R	radiant heat exchange	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}$
REHL	respiratory evaporative heat loss	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}$
RH	humidity, relative	%
RMR	metabolic rate, resting	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$
S	storage of body heat	$W, W \cdot m^{-2}, W \cdot m^{-3}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$
SMR	metabolic rate, standard	$W, W \cdot m^{-2}, , W \cdot m^{-3}, W \cdot kg^{-1}, W \cdot kg^{-3/4}$
SWR	sweat rate	$mg \cdot s^{-1}, mg \cdot m^{-2} \cdot s^{-1}$
T_a	temperature , ambient	°C
T_c, T_{co}	temperature, core	°C
$\overline{T}_b$	temperature, mean body	°C
T_{db}	temperature, dry bulb	°C

APPENDIX 2. Symbols Used in the Glossary

T_{dp}	temperature, dew-point	°C
T_{eff}	temperature, effective	°C
T_g	temperature, globe	°C
T_o	temperature, operative	°C
$\overline{T}_r$	temperature, mean radiant	°C
$\overline{T}_s, \overline{T}_{sk}$	temperature, mean skin	°C
T_{wb}	temperature, wet bulb	°C
TNZ	thermoneutral zone	°C
$\dot{V}O_{2max}$	rate of oxygen consumption, maximum	$ml \cdot s^{-1}$, $l \cdot min^{-1}$
W	body mass*	kg
W	work rate (mechanical power)	W, $W \cdot m^{-2}$, $W \cdot m^{-3}$, $W \cdot kg^{-1}$, $W \cdot kg^{-3/4}$
c	specific heat	$J \cdot kg^{-1} \cdot °C^{-1}$
h	general heat transfer coefficient	$W \cdot m^{-2} \cdot °C^{-1}$
$h_{comb.}$,h	heat transfer coefficient, combined nonevaporative	$W \cdot m^{-2} \cdot °C^{-1}$
h_c	heat transfer coefficient, convective	$W \cdot m^{-2} \cdot °C^{-1}$
h_D	mass transfer coefficient (diffusion)	$m \cdot s^{-1}$
h_e	heat transfer coefficient, evaporative	$W \cdot m^{-2} \cdot kPa^{-1}$, $W \cdot m^{-2} \cdot Torr^{-1}$
h_k	heat transfer coefficient, conductive	$W \cdot m^{-2} \cdot °C^{-1}$
h_r	heat transfer coefficient, radiative (linear)	$W \cdot m^{-2} \cdot °C^{-1}$
$\dot{m}$	mass transfer rate	$kg \cdot s^{-1}$
w	wettedness, skin	ND
α	radiant absorptance, total	ND
α	diffusivity, thermal	$m^2 \cdot s^{-1}$
β	thermal expansion, coefficient of volume	K^{-1}
γ	humidity, absolute	$kg \cdot m^{-3}$
ε	emissivity	ND
$\varepsilon_{(\theta,\phi)}$	emissivity, directional	ND
ε_λ	emissivity, spectral	ND
ε_h	emissivity, hemispherical	ND
ε_w	emissivity, window	ND
η	work efficiency	%
θ	angular coordinate, vertical	rad
λ	thermal conductivity	$W \cdot m^{-1} \cdot °C^{-1}$
λ, LHV	latent heat of vaporization	$J \cdot g^{-1}$
λ	wavelength	m, µm, nm
ρ	density	$kg \cdot m^{-3}$
ρ	reflectance, radiation	ND
σ	Stefan-Boltzmann constant	$W \cdot m^{-2} \cdot K^{-4}$ (5.67×10^{-8})
τ	transmittance, radiation	ND
ϕ	angular coordinate, horizontal	rad

APPENDIX 2. Symbols Used in the Glossary

ϕ	humidity, relative	ND
ϕ	radiant flow	W
ϕ_λ	radiant flow, spectral	$W \cdot nm^{-1}$
Ω	solid angle	sr

* The term weight (instead of the correct term mass) is conventionally used

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