Metabolism
ANS 215
Physiology and Anatomy of Domesticated Animals

I. Body Temperature

A. Chemical reaction of the body and therefore body functions are affected by body temperature

1. Each species has an associated average body temperature.

Average Rectal Temperatures of Various Species

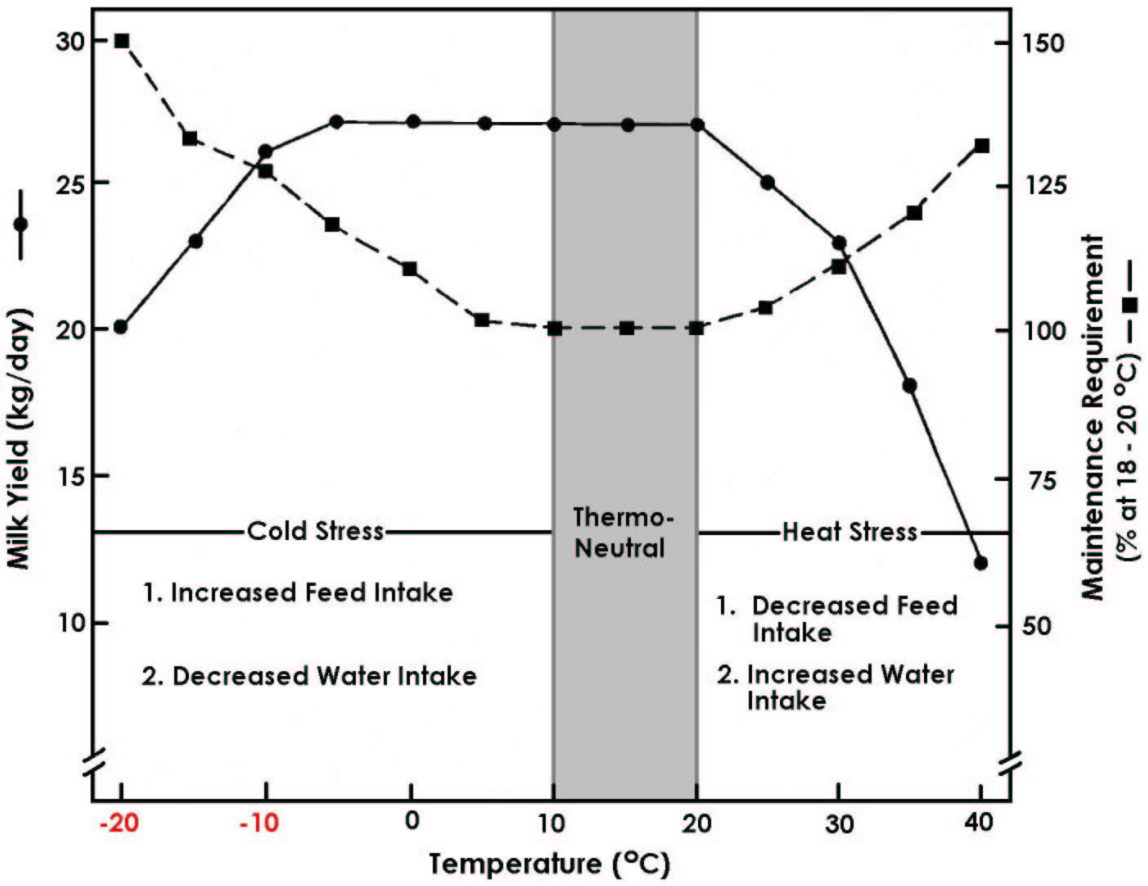
	Average		Range	
Animal	**°C**	**°F**	**°C**	**°F**
Stalion	**37.6**	**99.7**	**37.2 - 38.1**	**99.0 - 100.6**
Mare	**37.8**	**100**	**37.3 - 38.2**	**99.1 - 100.8**
Donkey	**37.4**	**99.3**	**36.4 - 38.4**	**97.5 - 101.1**
Camel	**37.5**	**99.5**	**34.2 - 40.7**	**93.6 - 105.3**
Beef cow	**38.3**	**101**	**36.7 - 39.1**	**98.0 - 102.4**
Dairy cow	**38.6**	**101.5**	**38.0 - 39.3**	**100.4 - 102.8**
Sheep	**39.1**	**102.3**	**38.3 - 39.9**	**100.9 - 103.8**
Goat	**39.1**	**102.3**	**38.5 - 39.7**	**101.3 - 103.5**
Pig	**39.2**	**102.5**	**38.7 - 39.8**	**101.6 - 103.6**
Dog	**38.9**	**102**	**37.9 - 39.9**	**100.2 - 103.8**
Cat	**38.6**	**101.5**	**38.1 - 39.2**	**100.5 - 102.5**
Rabbit	**39.5**	**103.1**	**38.6 - 40.1**	**101.5 - 104.2**
Chicken (daylight)	**41.7**	**107.1**	**40.6 - 43.0**	**105.0 - 109.4**

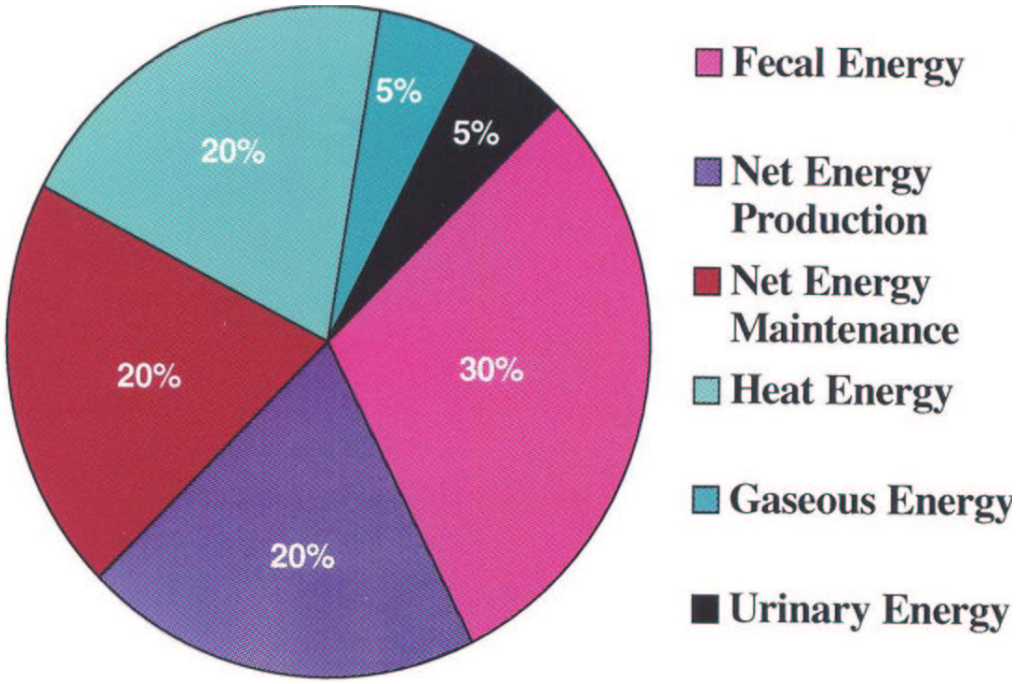
B. Factors influencing body temperature:

1. basal metabolism – resting heat production
2. basal metabolic rate is not altered by temperatures within the thermoneutral zone (see diagram below)
3. When environmental temperatures fall below or exceed the thermoneutral zone, the basal metabolic heat output rises.
4. Increasing maintenance costs decreases profitability of raising farm animals.

C. Methods of heat loss

1. Conduction – requires thermal gradient and physical contact
2. Convection – requires thermal gradient and movement of air or water over a surface
3. Radiation – requires a thermal gradient and moves at the speed of light
4. Evaporation – requires a vapor-pressure gradient and is favored when the other three routes of heat loss are compromised


Milk Yield (kg/day)
Maintenance Requirement (% at 18 - 20 °C)
30
25
20
15
10
150
125
100
75
50
Cold Stress
Thermo-Neutral
Heat Stress
1. Increased Feed Intake
2. Decreased Water Intake
1. Decreased Feed Intake
2. Increased Water Intake
-20
-10
0
10
20
30
40
Temperature (°C)


5%
5%
20%
20%
30%
20%
Fecal Energy
Net Energy Production
Net Energy Maintenance
Heat Energy
Gaseous Energy
Urinary Energy

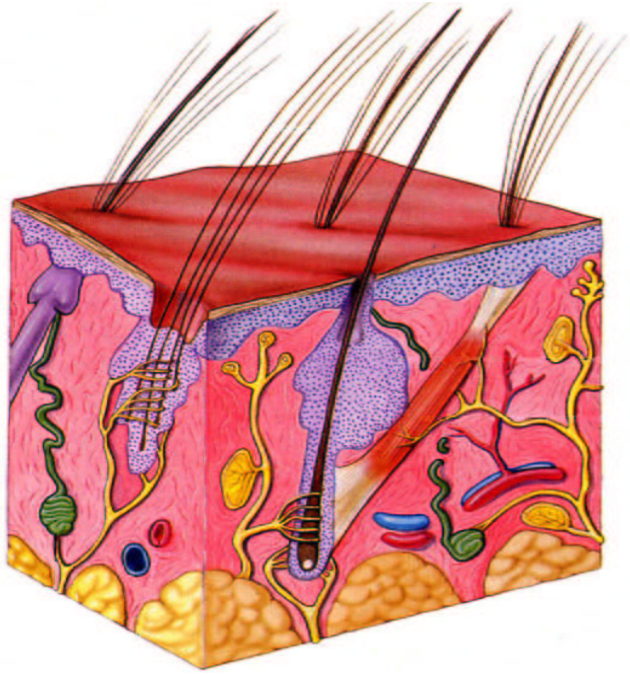
D. Total energy expenditure:
    1. 20% is lost as heat
    2. 20% utilized in maintenance
    3. 5% lost in gas production in digestive tract
    4. 5% lost in urinary excretion
    5. 20% utilized in productive processes

E. Basal metabolism
    1. reflects the energy requirement for a given animal in the fasting and resting state
    2. can be calculated if body weight, surface area, and feed composition and quantity are know

F. Total heat content
    1. If the body mass and temperature are known, then the total heat content of an animal can be calculated.
    2. Example: a dairy cow with body temp. of 38.5ºC weighing 1200 lbs.
        1200 lbs. = 545.45 kg = 545450 g
        70% H_2O, so 0.70 x 545450g = 381.815 kcal
        30% dry matter with conductivity of 0.6 of H_2O, so
            0.30 x 0.60 x 163635 g = 29.454 kcal
        Total heat contained = 793.084 kcal

II. Physiologic Responses to Heat and Cold

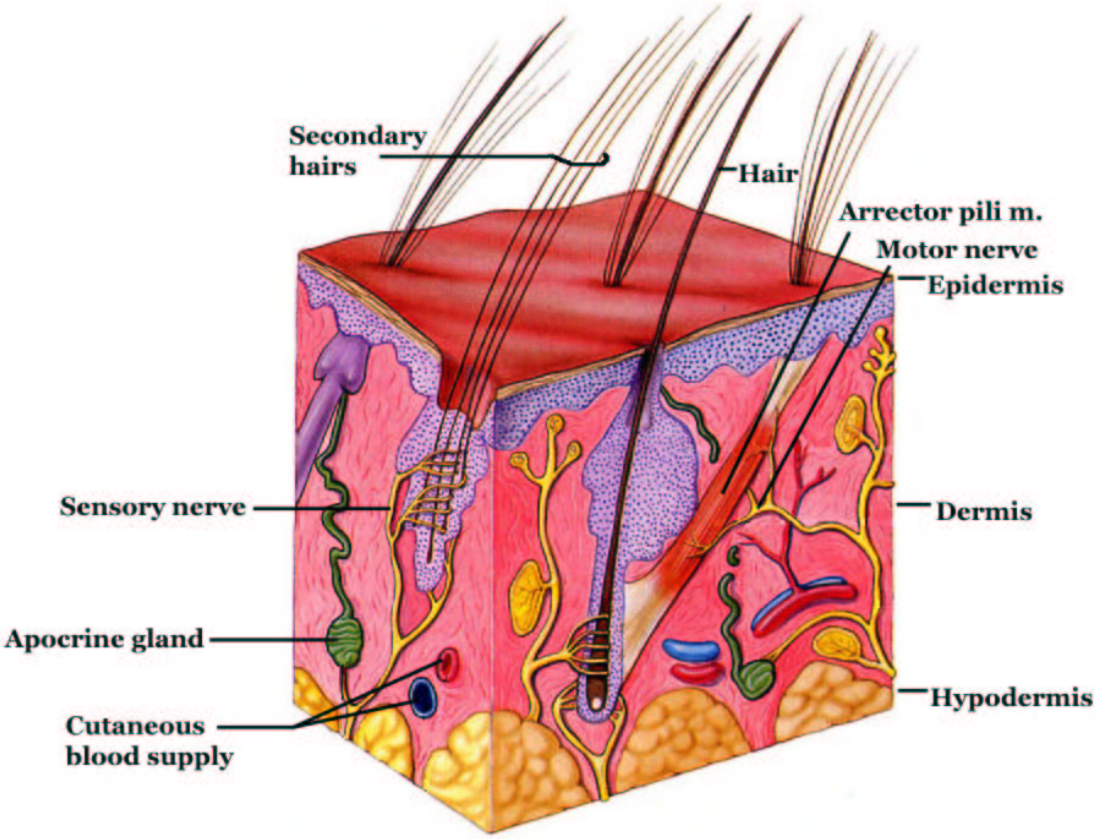
A. Heat
    1. blood flow to skin surface is tightly regulated to control degree of heat loss
    2. vasodilation of surface vessels is maximal at upper critical temperature



Schematic section of skin. Note dogs have a more extensive network of blood vessels superior to the layer of adipose tissue.

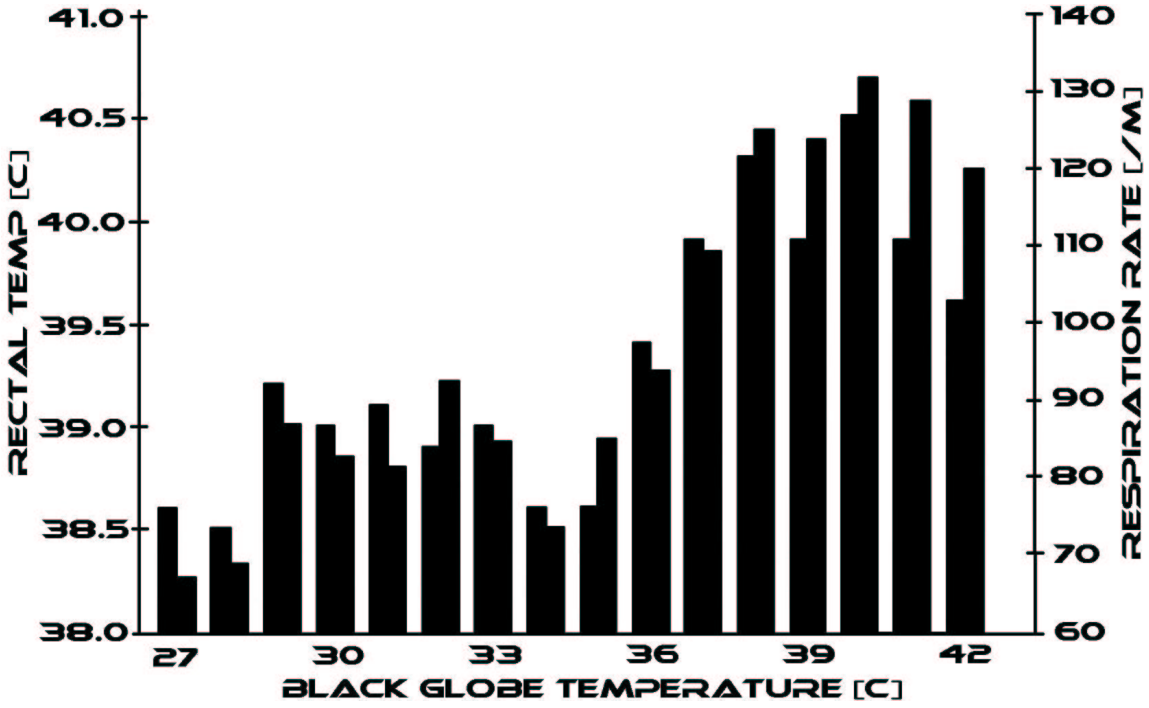
3. Upper and lower critical temperatures are extreme points of the thermoneutral zone, where all physical means of adjusting body temperature have been exhausted.

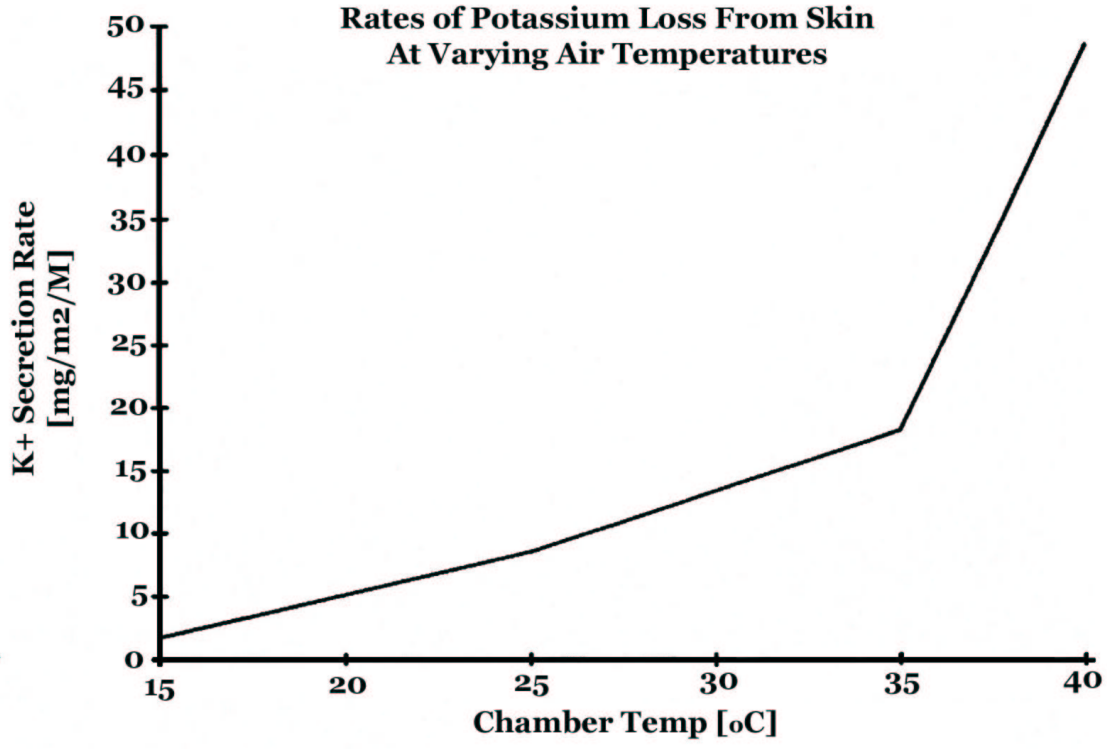
B. Evaporative heat loss
   1. increased by sweating and panting
      a. two types of sweat glands
         i. apocrine
            - found in horses, dogs, cattle, swine
               - composition of sweat varies among species
               - the horse is most prolific sweater
         ii. eccrine
            - found in humans



Labeled schematic representation of nerve supply and glands of the skin. Note sebaceous gland not drawn.

      b. Panting
         i. common in domestic animals that sweat poorly
         ii. comes at a high cost to productivity due to adverse effects on feed intake





B. Cold

1. vasoconstriction of blood vessels within the thermoneutral zone
2. activation of counter-current heat exchange mechanisms within the thermoneutral zone

3. piloerection
4. Increased heat production outside of the thermoneutral zone:
    a. shivering thermogenesis
    b. non-shivering thermogenesis – brown adipose tissue
    c. increased basal metabolism
        i. increased feed intake

III. Escaping Environmental Extremes

A. Hibernation
1. process of war blooded animals
2. radical decrease in basal metabolic rate
3. body temperature drops
4. animals spontaneously come out of hibernation

B. Estivation
1. similar to hibernation, but induced by heat and low water
2. animals reduce metabolism until stress period is over

C. Migration
1. move to better environment for breeding purposes or to survive

IV. Abnormal Temperatures

A. Fever – altered hypothalamic set-point caused by bacterial endotoxins
1. characterized by chills during period of temperature increase; when set-point returns to normal, sweating is initiated
2. hot flashes
    a. altered set-point due to abnormally high concentrations of gonadotropin releasing hormone
3. hyperthermia
    a. caused by heat stress
4. hypothermia
    a. caused by cold stress