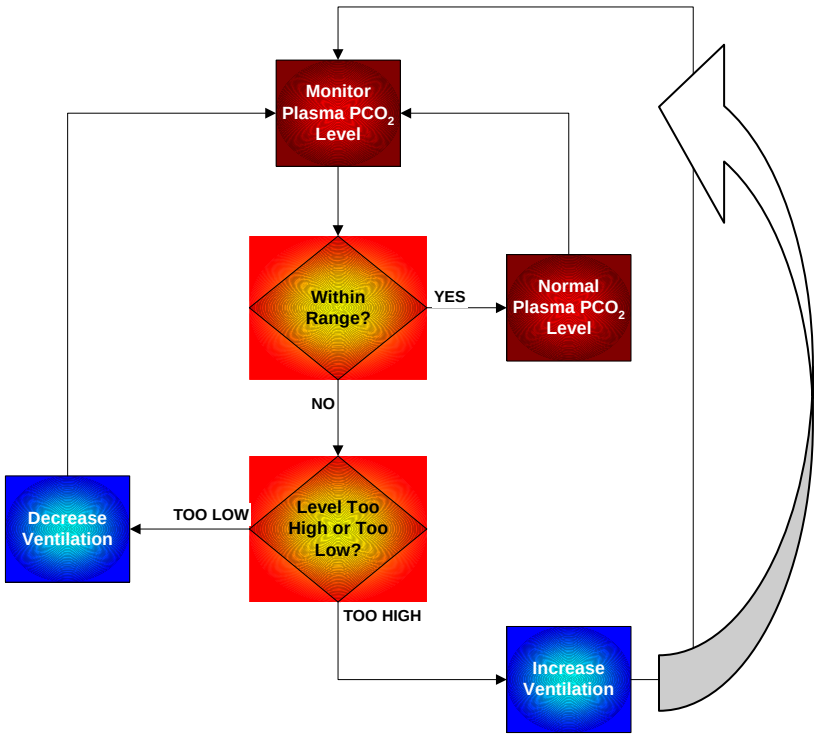
Hiking and Internal Heat

Our hiker takes a long walk during the day and experiences:

- Increase in heart rate (how much of an increase depends on how long the walk is, how steep or rigorous the trail, and the overall athletic condition of the hiker – but an increase will occur as he hikes, since his muscles are working harder and demanding energy).
- Increase in metabolic rate (the hiker is working harder by this activity; his metabolism will increase to meet his demands for energy).
- Increase in ventilation follows increase in metabolism[1], prompting the hiker to breathe more often.



- Increase in body temperature, since some of the energy liberated by activity will be released as metabolic heat. Muscle contraction causes friction and friction results in heat; hydrolysis of ATP generates heat.

[1] Plate 56, Kapit

- Increase in blood flow (vasodilation). Internal heat is transferred to the skin through the blood. Body flushes, skin warms up (discussed in greater detail in Unit 3, Q3.2/f).
- Increase in perspiration. Osmoregulation manages water content, and depending on his hydration level, this mechanism may kick in to conserve water and prevent dehydration. If our hiker is foolish, he will have been drinking flavored or sugared drinks and/or will not have been properly hydrated to begin with. Assuming he is experienced and not foolish, he will have been properly hydrated and will have carried an amount of water with him to replenish himself, depending on how long the walk and how vigorous – and he will avoid sugared, flavored drinks.
- Heat loss through evaporation (perspiration off his skin), radiation (heat transfer away from skin), convection (warmed air next to skin replaced with cooler air), and conduction (skin transfers heat to anything in contact with it) to keep the body cool and regulate internal temperature to approximately 37degC.
- Heat loss is tempered by atmospheric temperature and clothing conditions (assuming it is a nice warm, pleasant day when the sun is up and he has dressed in lighter weight, multi-layered clothing. He can peel off as he heats up. If he is smart and experienced, he will have dressed thus, or at least carried something extra with him in case he is delayed or lost and unable to return to his tent and campfire before nightfall.

Hiker returns to camp, sits by small fire, drinking hot soup:

- Decrease in heart rate (eventual return to at-rest rate).
- Decrease in metabolic rate and respiration (eventual return to at-rest rate). However, ingesting the soup will stimulate his metabolic rate and generate some amount of heat in the process.
- Decrease in body temperature (or better put, a return to normal at-rest state so that additional heat is not being generated internally due to higher metabolic rate related to being active.).
- Decrease in blood flow (vaso-constriction); decrease in perspiration and internal temperature stable at approximately 37degC (at least for the moment). Skin loses its flush. Our hiker may develop “goose bumps,” or a tightening around his hair follicles

as arrector pilli muscles contract causing hair to stand on end in an attempt to trap air against the skin (off course, unless this hiker is a gorilla, this “fur” reaction is not going to help much).

- Heat loss will continue through evaporation, radiation, convection, and conduction. Air has cooled and rate of heat loss will accelerate as night falls and air becomes cooler. If this guy is smart, he has removed his sweat-moistened clothing, donned either fresh clothing or his additional layers he previously removed, and dried the perspiration from his skin prior to plunking down in front of the fire while it gets dark (else he will get very cold very fast). An experienced hiker and camper will know to use woolen and/or silk clothing or synthetics specifically designed for trapping warmth and wicking moisture away from the skin, and he will have avoided the use of cotton clothing altogether. He will have his head covered and his feet dry.
  If he is not smart or experienced, he is already getting cold and uncomfortable, no doubt starting to shiver (or will begin very soon) in spite of the warm soup.
- Heat gain from fire via radiation (maybe enough to keep his feet from getting too cold if he places them near the fire). A small campfire will not generate enough heat for the hiker to maintain an internal temperature of 37degC if frost is forming on the tent flaps. Actually, if he is really smart, he will have removed his hiking boots and socks which have been dampened with perspiration and will have donned a fresh pair of socks, preferably woolen ones, and will have only his stocking feet facing the small fire, but distant enough to prevent torching his socks. His boots will be opened to the fire and drying, and he will put them back on later, warm and dry over his fresh socks. If he is really an experienced hiker, he may have a polypropylene sock layer under the wool, which will help wick moisture away from his sweaty feet to the wool where it can evaporate. Of course, if he isn’t very bright at all, he is still sitting in his clammy cotton socks inside his stinky wet hiking boots, and no doubt his feet are already giving up a great deal of heat as the cold night descends. If he is this foolish, he undoubtedly will not have a cap on his head either, and will give up a tremendous amount of body heat by exposing his head to frosty temperatures. If he is bald, he is really in trouble.
- One might like to suppose there will be an initial heat gain from the soup via conduction as it touches his tissues on the way to his stomach. Suppose the warm

soup actually does promote an increase in internal heat via conduction – this unfortunately will kick in the feedback mechanism to reduce his internal temperature if the soup caused the temperature of his blood to increase by more than 0.25degC. If he is sitting in wet clothing, shivering, trying to get warm with a small fire and a cup of soup, he is actually accelerating his heat loss. He is better off chucking the soup, putting on dry clothing, and climbing into his sleeping bag inside the tent with the flaps closed.[2]

- Eating the soup will generate a some degree of metabolic heat as his body ingests and digests the food, but it will not be enough to maintain the necessary 37degC on a dark frosty night.
- Heat loss will be tempered or controlled by layers of clothing and trapped air between the layers; losses can be further controlled or at least temporarily subdued by an insulating sub-cutaneous fat layer (the larger, the more insulating). Again, on a cold, frosty night, our hiker has no hope of maintaining his internal body heat unless he is sufficiently clothed against this kind of weather. Even clothed well, if he has not taken the appropriate actions after a vigorous day hike, he can put himself in the position of continuing to give up heat through damp clothing, regardless of how much of it he wears, particularly if he is not wearing fabrics that inherently insulate even when wet (as in the case of wool).

[2] This assumes, of course, that a cup of warm soup is capable of increasing the temperature of the blood by 0.25degC or more. I'm not sure that it is, but it is interesting to ponder. In this case, he would be better off having something cool to drink while wrapping up in a wool blanket inside his sleeping bag. The cool drink might trigger his body to attempt warming itself through shivering and teeth chattering, vaso-constriction would be triggered if it hadn't already been, he would get goose bumps as his hair stood on end; he might actually be able to warm himself and prevent hypothermia.

Bibliography

Kapit, Macey, Meisami. The Physiology Coloring Book. San Francisco: Benjamin/Cummings Science Publishing, 2000.

Lippincott Williams & Wilkins. Anatomy and Physiology. Second Edition. New York: Lippincott Williams & Wilkins, 2002.

Waugh, Anne. Ross and Wilson: Anatomy and Physiology in Health and Illness. Spain: Elsevier Health, 2004.