ATHENAEUM SOCIETY

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April 3, 2025

A TABOO-BUSTING ROMP THROUGH THE SHAME, STINK, AND STRANGE SCIENCE OF SWEATING [1] [2]

In the summer of 1996, a woman walked into the dermatology 0ffice at Tygerberg Hospital in suburban Cape Town with an unusual complaint. Her sweat was red. She was understandably alarmed. But the medical team? They were intrigued.

"It was fantastically interesting," says Carena de Beer, a scientist who analyzed the case. "We spent months trying to figure out what was happening. Here was a healthy person, a nurse, in her twenties. The moment she started sweating, pink spots would appear on her white uniform." By the end of a shift, the nurse's underwear and uniform were sometimes bright red, particularly around the collar, back, and armpits. "Every night she soaked her stained clothes for 2 to 3 hours before washing them just to get the color out," de Beer says. "Not only was it very disconcerting to have something so abnormal happening to her body, but the nurse was also concerned about her job. In a hospital, nurse uniforms need to be white. She felt the red sweat was socially and professionally unacceptable."

Dermatologists see all manner of skin curiosities, but red sweat is so unusual that de Beer and dermatologist Jacques Cilliers published a scientific paper about it: "The Case of the Red Lingerie - Chrornhidrosis Revisited." This nurse, it turns out, was not the first person to produce pigmented perspiration, nor would she be the last. The medical literature features many reports of sweat that has turned green, blue, yellow, brown, or red, with causes as varied as rare genetic conditions and workplace chemical exposure.

Sweating may be one of our weirdest biological functions, but it's also one of our most vital and least understood. In *The Joy of Sweat*, Sarah Everts delves into its role in the body—and in human history.

Why is sweat salty? Why do we sweat when stressed? Why do some people produce colorful sweat? And should you worry about Big Brother tracking the hundreds of molecules that leak out in your sweat—not just the stinky ones - but the ones that reveal secrets about your health and vices?

Everts's entertaining investigation takes readers around the world—from Moscow, where she participates in a dating event in which people sniff sweat in search of love, to New Jersey, where companies hire trained armpit sniffers to assess the efficacy of their anti-sweat products. In Finland, Everts explores the delights of the legendary smoke sauna and the purported health benefits of good sweat, while in the Netherlands she slips into the sauna theater scene, replete with costumes, special effects, and towel dancing.

Along the way, Everts traces humanity's long quest to control sweat, culminating in the multibillion-dollar industry for deodorants and antiperspirants. And she shows that while sweating can be annoying, our sophisticated temperature control strategy is one of humanity's most powerful biological traits.

Deeply researched and written with great zest, *The Joy of Sweat* is a fresh take on a gross but engrossing fact of human life.

Perspiration, also known as **sweat**, is the fluid secreted by sweat glands in the skin of mammals.

Two types of sweat glands can be found in humans: eccrine glands and apocrine glands. The eccrine sweat glands are distributed over much of the body and are responsible for secreting the watery, brackish sweat most often triggered by excessive body temperature. Apocrine sweat glands are restricted to the armpits and a few other areas of the body and produce an odorless, oily, opaque secretion which then gains its characteristic odor from bacterial decomposition.

In humans, sweating is primarily a means of thermoregulation, which is achieved by the water-rich secretion of the eccrine glands. Maximum sweat rates of an adult can be up to 0.53–1.06 US gal per hour or 2.6–3.7 US gal per day, but is less in children prior to puberty. Evaporation of sweat from the skin surface has a cooling effect due to evaporative cooling. Hence, in hot weather, or when the individual's muscles heat up due to exertion, more sweat is produced. Animals with few sweat glands, such as dogs, accomplish similar temperature regulation results by panting, which evaporates water from the moist lining of the oral cavity and pharynx.

Although sweating is found in a wide variety of mammals, relatively few (apart from humans, horses, and some primates) produce sweat in order to cool down. In horses, such cooling sweat is created by apocrine glands and contains a wetting agent, the protein latherin which transfers from the skin to the surface of their coats.

Sweat contributes to body odor when it is metabolized by bacteria on the skin. Medications that are used for other treatments and diet also affect odor. Some medical conditions, such as kidney failure and diabetic ketoacidosis, can also affect sweat odor.

Diaphoresis is a non-specific symptom or sign, which means that it has many possible causes. Some causes of diaphoresis include physical exertion, menopause, fever, ingestion of toxins or irritants, and high environmental temperature. Strong emotions (anger, fear, anxiety) and recall of past trauma can also trigger sweating.

Diaphoresis may be associated with some abnormal conditions, such as hyperthyroidism and shock. If it is accompanied by unexplained weight loss, fever/chills, or by palpitations, shortness of breath, unconsciousness, fatigue, dizziness, muscle pain, nausea, vomiting, diarrhea, and chest discomfort, it suggests serious illness.

Diaphoresis is also seen in an acute myocardial infarction (heart attack), from the increased firing of the sympathetic nervous system, and is frequent in serotonin syndrome, which can result in serious sickness or even death. Diaphoresis can also be caused by many types of infections, often accompanied by high fever and/or chills which can trigger the result of hyperthermia. Most infections can cause some degree of diaphoresis and it is a very common symptom in some serious infections such as malaria and tuberculosis. In addition, pneumothorax can cause diaphoresis with splinting of the chest wall. Neuroleptic malignant syndrome and other malignant diseases (e.g. leukemias) can also cause diaphoresis.

Diabetics relying on insulin shots or oral medications may have low blood sugar (hypoglycemia), which can also cause diaphoresis.

Drugs (including caffeine, morphine, alcohol, antidepressants and certain antipsychotics) may be causes, as well as withdrawal from alcohol, benzodiazepines, or narcotic painkiller dependencies. Sympathetic nervous system stimulants such as cocaine and amphetamines have also been associated with diaphoresis. Mercury is well known for its use as a diaphoretic, and was widely

used in the 19th and early 20th century by physicians to "purge" the body of an illness. However, due to the high toxicity of mercury, secondary symptoms would manifest, which were erroneously attributed to the former disease that was being treated with mercurials.

Infantile acrodynia (childhood mercury poisoning) is characterized by excessive perspiration. A clinician should immediately consider acrodynia in an afebrile child who is sweating profusely.

Some people can develop a sweat allergy. The allergy is not due to the sweat itself but instead to an allergy-producing protein secreted by bacteria found on the skin. Tannic-acid has been found to suppress the allergic response along with showering.

Millions of people are affected by hyperhidrosis, but more than half never receive treatment due to embarrassment, lack of awareness, or lack of concern. While it most commonly affects the armpits, feet, and hands, it is possible for someone to experience this condition over their whole body. The face is another common area for hyperhidrosis to be an issue. Sweating uncontrollably is not always expected and may be embarrassing to people with the condition. It can cause both physiological and emotional problems in patients. It is generally inherited. It is not life-threatening, but it is threatening to a person's quality of life. Treatments for hyperhidrosis include antiperspirants, and surgical removal of sweat glands. In severe cases, botulinum toxin injections or surgical cutting of nerves that stimulate the excessive sweating may be an option.

Night sweats, also known as nocturnal hyperhidrosis, is the occurrence of excessive sweating during sleep. The person may or may not also perspire excessively while awake.

One of the most common causes of night sweats in women over 40 is the hormonal changes related to menopause and perimenopause. This is a very common occurrence during the menopausal transition years.

While night sweats might be relatively harmless, it can also be a sign of a serious underlying disease. It is important to distinguish night sweats due to medical causes from those that occur simply because the sleep environment is too warm, either because the bedroom is unusually hot or because there are too many covers on the bed. Night sweats caused by a medical condition or infection can be described as "severe hot flashes occurring at night that can drench sleepwear and sheets, which are not related to the environment". Some of the underlying medical conditions and infections that cause

these severe night sweats can be life-threatening and should promptly be investigated by a medical practitioner.

Sweating allows the body to regulate its temperature. Sweating is controlled from a center in the preoptic and anterior regions of the brain's hypothalamus, where thermosensitive neurons are located. The heat-regulatory function of the hypothalamus is also affected by inputs from temperature receptors in the skin. High skin temperature reduces the hypothalamic set point for sweating and increases the gain of the hypothalamic system in response to variations in core temperature. Overall, however, the sweating response to a rise in hypothalamic ('core') temperature is much larger than the response to the same increase in average skin temperature.

Sweating causes a decrease in core temperature through evaporative cooling at the skin surface. As high energy molecules evaporate from the skin, releasing energy absorbed from the body, the skin and superficial vessels decrease in temperature. Cooled venous blood then returns to the body's core and counteracts rising core temperatures.

There are two situations in which the nerves will stimulate the sweat glands, causing perspiration: during physical heat and during emotional stress. In general, emotionally induced sweating is restricted to palms, soles, armpits, and sometimes the forehead, while physical heat-induced sweating occurs throughout the body.

People have an average of two to four million sweat glands, but how much sweat is released by each gland is determined by many factors, including sex, genetics, environmental conditions, age and fitness level. Two of the major contributors to sweat rate are an individual's fitness level and weight. If an individual weighs more, sweat rate is likely to increase because the body must exert more energy to function and there is more body mass to cool down. On the other hand, a fit person will start sweating earlier and more readily. As someone becomes fit, the body becomes more efficient at regulating the body's temperature and sweat glands adapt along with the body's other systems.

Human sweat is not pure water; though it contains no protein, it always contains a small amount of solute. When a person moves from a cold climate to a hot climate, adaptive changes occur in the sweating mechanisms of the person. This process is referred to as acclimatization: the maximum rate of sweating increases and its solute composition decreases. The volume of water lost in sweat daily is highly variable, ranging from 100 to 8,000 millilitres per day. During average intensity exercise, sweat losses up to 0.53 US gal of water/hour. Horses have a thick, waterproofed, hairy coat that would

normally block the rapid translocation of sweat water from the skin to the surface of the hair required for evaporative cooling. To solve this, horses have evolved a detergent-like protein, latherin, that they release at high concentrations in their sweat. Their perspiration unlike humans is created by apocrine glands. This protein, by wetting the horses' coat hairs facilitate water flow for cooling evaporation. The presence of this protein can be seen in the lathering that often occurs on the coats of sweating horses, especially when rubbed. In hot conditions, horses during three hours of moderate-intensity exercise can loss 7.9 to 9.2 US gal of water and 3.5 oz of sodium, 198 grams (7.0 oz) of chloride and 1.6 oz) of potassium.

Many other trace elements are also excreted in sweat, again an indication of their concentration. Some exogenous organic compounds make their way into sweat as exemplified by an unidentified odiferous "maple syrup" scented compound in several of the species in the mushroom genus *Lactarius*. In humans, sweat is hypoosmotic relative to plasma (i.e. less concentrated). Sweat is found at moderately acidic to neutral pH levels, typically between 4.5 and 7.0.

Artificial perspiration is also available for in-vitro testing, and contains 19 amino acids and the most abundant minerals and metabolites in sweat.

There is interest in its use in wearable technology. Sweat can be sampled and sensed non-invasively and continuously using electronic tattoos, bands, or patches. However, sweat as a diagnostic fluid presents numerous challenges as well, such as very small sample volumes and filtration (dilution) of larger-sized hydrophilic analytes. Currently the only major commercial application for sweat diagnostics is for infant cystic fibrosis testing based on sweat chloride concentrations.

If you think that sweating is a disgusting way to cool down in hot temperatures, consider the alternatives. You could be one of the many animals that rely on other bodily fluids to evaporate away unwanted body heat-think diarrhea, vomit, saliva, and urine.

Take the male South Australian fur seal. It lounges around on rocks in the sun hoping the ladies will impressed by its real estate, a critical factor for finding a mate.

These creatures are seriously territorial about their beach-side boulders. No self-respecting male seal wants to share a rock with another guy. But the Australian sun is hot, many rocks do not have shade, and leaving one's rock to take a cooling dip can be risky for the real-estate agenda and quite possibly the mating agenda. In 1973, the biologist Roger Gentry measured

the copulation frequency males who abandoned their landlocked rocks to cool down in the water: Those that left their rocks on hot days for a swim got half as much sex as the males that stayed put.

This is where urine comes in. At high temperatures, land-locked male seals stood on all four flippers and urinated on the rocks, wetting the hair of the belly and rear flippers. They then lay on one side and extended the wet rear flipper into the air," Gentry wrote. The pee evaporating off the flipper cooled the overheated animal, the same way sweat evaporates a human arm cools an overheated body. This pee-based cooling strategy has its own scientific term: urohidrosis, *uro* for urine and *hidrosis* for sweating.

Of the bodily fluids we could ostensibly use to evaporate unwanted heat off the surface of our body, surely sweat is preferable to urine? Sweat is certainly better than vomit, the honeybee's favored choice. On a sizzling summer day, a honeybee collecting nectar in a patch of blooming flowers can easily get too hot. Tiny wings working heroically to keep a lumbering body airborne produce a lot of heat-and can make you wonder whether evolution's aeronautics department dropped the ball with these insects. To avoid overheating, bees "regurgitate their stomach contents from the mouth and spread the liquid all over themselves with their forefeet," noted biologist Bernd Heinrich in his delightful book *Why We Run.*

It gets worse for our little flying friends.

Or to be accurate. it gets worse for the overheated bee's hive mates. Honeybees are social creatures and nectar is a valuable commodity- not something to be wasted. So when the bee returns to the hive covered in vomit, its colony mates retrieve the nectar by "licking off the residual solids that are left after the water has evaporated," according to Heinrich. We could all take a lesson in efficient economization of resources from these insects.

Or consider the case of storks and vultures. To cool down, these birds "poop on their own legs," explained Danielle Levesque, an evolutionary physiologist at the University of Maine. "And then they increase blood circulation to their legs." The blood traveling along the birds' lower extremities is cooled by the evaporation, which reduces overall body temperature by several degrees. As Heinrich put it, "a turkey vulture sitting on a fence post in the sun on a hot day, calmly and deliberately defecating on its naked legs is behaving in a way that makes sense."

temperature in the animal's core.

I close this paper with the suggestion that "Don't sweat the small stuff; it's all small stuff".

[1)] *The Joy of Sweat*, Sarah Everts

[2)] Wikipedia Encyclopedia

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