BACKPACKING MEDICINE

A COURSE OF STUDY ON WILDERNESS MEDICINE
FOR HIKERS, BACKPACKERS, AND TREKKERS

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Table of Contents

Click on a chapter to advance

Section 1: Weather

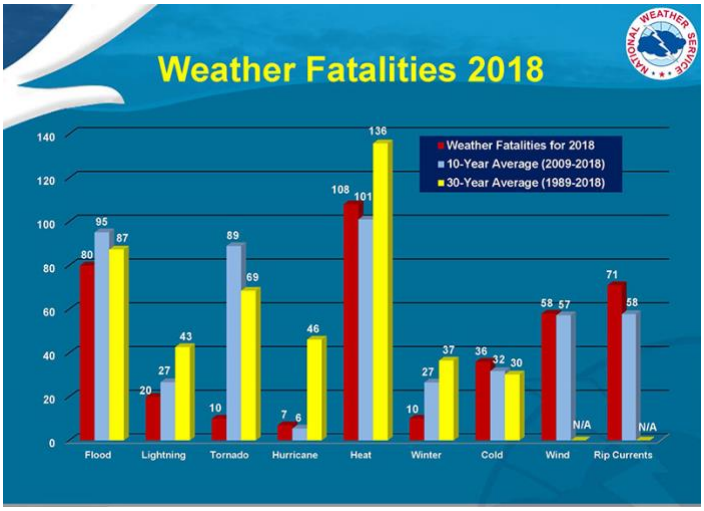
Section 2: Medical Aspects of Backpacking Gear

Section 3: Prevention and Safety

Section 4: Special Topics in Backpacking Medicine

Chapter 1: Flash Floods

In September 2015, a flash flood in Zion National Park killed seven highly trained canyoners as they navigated Keyhole Canyon. The group had been planning their trip into Keyhole for months and decided to ignore a moderate level warning of flooding from the National Weather Service the morning before entering the canyon. What began as a 40% chance of rain turned into a devastating flash flood that took their lives. The victims were described as extremely cautious and experienced. The same flood continued on to kill twelve members of a small religious community in Southern Utah. Flash Floods are extremely dangerous, even for the most experienced outdoorsmen, and must be treated with extreme caution.



THE UNPREDICTABILITY OF FLASH FLOODS

A flash flood is a flood that begins within six hours of heavy rainfall. The danger associated with flash floods is due to their sudden onset, which leaves little time for people to prepare or evacuate. Flash flooding is the second leading cause of natural disaster-related deaths in the U.S., with approximately 100 deaths occurring each year. While they can be particularly problematic in the backcountry, flash floods are not restricted to wilderness areas and can happen anytime and anywhere.

Weather conditions, as well as topography and soil conditions, influence the formation of flash floods and should be considered when planning a wilderness activity. Arid deserts are particularly susceptible to flash flood conditions due to the often-impermeable clay-like soil, the funneling effects of slot canyons, and the infrequency of storms. A storm occurring many miles away can quickly flood a desert area. This is a major problem because when adventurers go into the backcountry, they see blue skies above them and may have no idea that it is raining heavily 30 miles away. A flash flood can present four to five hours after rainfall and after the storm has passed.

The head of a flash food is often choked with debris, dirt, and rock, giving it a dark brown color and slowing down its speed, causing water to back up behind it. It is a 'moving dam', and it has incredible momentum. Even a small flood could knock a person over. A surprising fact to most is that more than half of the flood-related fatalities in the U.S. occur in vehicles such as cars or trailers. Being inside a vehicle during a flood can offer a false sense of security, when in fact, most vehicles lose complete control in less than six inches of water and begin to float in a foot of water. Vehicles often flip once floated, trapping their passengers. Never attempt to drive through a flooded area. You need to abandon your vehicle if it does become surrounded by water and seek higher ground. It is not uncommon for trees or even boulders to be carried by floodwaters. This debris has the potential to harm or kill anyone or any animal in its path. It is difficult to gauge the speed, depth, and contents of floodwater, and for that reason, one should never attempt to cross flowing flood water. If you are caught in a flood, seek higher ground immediately.

The best way to prevent flood-related injuries is prevention through planning and exercising caution when conditions are variable. When planning a trip, it is important to be aware of the flooding potential for the immediate backcountry area you will be in. As well, you should be aware of the drainage potential and slope of the land. Remember, flash floods usually occur hours after a rainstorm has ended. If the conditions are wrong, "turn around, don't drown" (TADD).

CLICK HERE to take a practice EXAM on Flash Floods

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Chapter 2: Lightning

Background

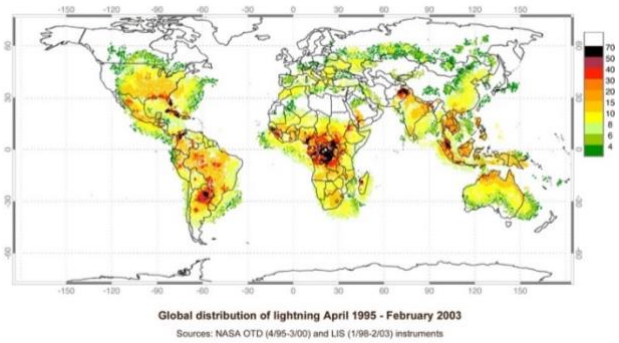
The power of lightning is immense. For every ten feet of ascension through the air, there is a 300-volt potential difference in electricity. This amounts to approximately 380,000 volts at the top of the atmosphere. This powerful "battery" tries to discharge through lightning strikes, striking the earth more than 100 times each second and 8 million times per day.

Worldwide, approximately 50,000 thunderstorms occur per day that may result in forest fires, injury to animals and people, damage to electrical and communication lines, and electronics, leading to millions of dollars in downtime for businesses.
There are approximately 240,000 lightning incidents worldwide each year. The annual fatality count is not known, and estimates vary. One view lists the annual global death toll at 6,000. However, the National Geographic estimates that about 2,000 people are killed worldwide by lightning. In using this lower number, this means that a person roughly has a 1 in 100,000 chance of falling victim to lightning in their lifetime.

According to the National Oceanic and Atmospheric Administration (NOAA), over the last 20 years, the United States has averaged 51 annual lightning strike fatalities. This places the number Lightning fatalities as the second highest in the United States, behind deadly flooding. About 90 percent of people struck by lightning are estimated to survive, but they often suffer from long-lasting neurological damage.

TYPES OF ISSUES ENCOUNTERED WITH LIGHTNING

Lightning Hotspots Worldwide



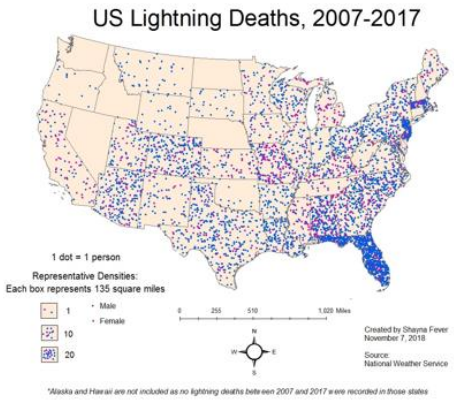
Global distribution of lightning April 1995 - February 2003
Sources: NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments

As people travel into the wilderness, it's essential to know the risks of lightning.

Thunderbolts often rain down with great fervor in tropical central Africa. The weather patterns in Africa bring in warm air from the Atlantic Ocean that collides with mountains, producing many thunderstorms and lightning year-round.
Another lightning hotspot is the Himalaya, where the mountainous topography forces the convergence of air masses to rise from the Indian Ocean. The North and South Poles, however, rarely experience thunderstorms and, therefore, have almost no lightning. In the United States, lightning researchers estimate that 22 million lightning flashes strike the ground each year. The most lightning prone region is Florida, on the Gulf Coast, which has, on average, 12 flashes of lightning per square kilometer per year.

Know When You are at Risk

The ***highest*** risk is for people in an open field, a sports park, or in/near water during thunderstorms. This group accounts for just over half of all deaths from lightning strikes. Swimming is particularly dangerous during thunderstorms with lightning. Not only do swimmers protrude from the water, which presents a potential channel for electrical discharge, but also because water is a good conductor of electricity.



Lightning is attracted to tall objects such as trees. Trees are frequently struck, making this the ***second*** highest unsafe location for someone to stand beneath.

Playing on a beach in the open is the ***third*** most common place where people are struck and killed by lightning. Many farmers and ranchers are struck and killed by lightning while working on or near farm equipment, making this the ***fourth*** highest group at risk. Lightning can, and often does, strike in the same place twice.

Location of Lightning Deaths	**Percentage**
Open fields, sport parks, in/on water	54%
Under trees	23%
On beaches	12%
Working on farm equipment	7%
Other	
Standing near open windows, riding a bike	4%

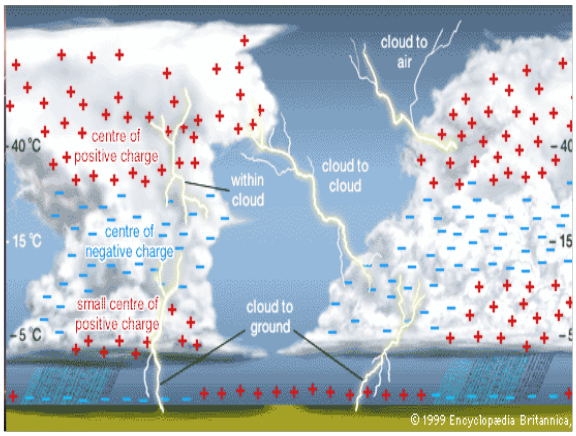
Far more injuries and deaths occur in tropical and developing countries. Complicating the increased risk people suffer in these countries because of higher lightning density, poor housing, and greater everyday exposure are the superstitions that may cause inadequate prevention and mitigation. Many people in these countries believe in two kinds of lightning: "natural lightning" and "man-made lightning" that can be called down by witches or prevented with charms, herbs, and burying something under a structure as it is being built. Some believe that anyone injured by lightning must be cursed, and they will shun the entire family afterward. Families have been forced to uproot and move to villages where their history is not known

The Physics of Lightning

As lightning connects from the clouds to the ground, the second stroke of lightning will return from the ground to the clouds (upward streamer) following the same channel as the first strike. The heat from the electricity of this return stroke raises the temperature of the surrounding air to around 27,000 C° (48,632 F°). The heated air is compressed, raising the air from 10 to 100 times the normal atmospheric pressure. The compressed air explodes outward, forming a shock wave of compressed particles in every direction. Like an explosion, the rapidly expanding waves of compressed air create a loud, booming burst of noise that we call thunder. If a person is near this wave, significant trauma is likely.

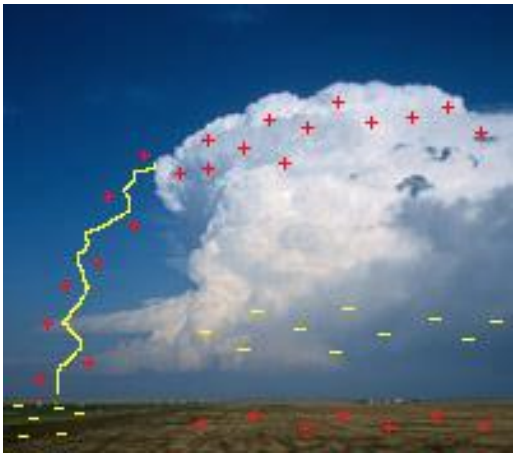
Most experts define ***four*** primary types of lightning:

1. The first is ***intra-cloud***, which occurs within a single thunder- cloud and is the most common form of lightning.
2. The second is ***cloud to cloud***, which starts and ends between two different thunderclouds. This is the second most common form of lightning. These two types of lightning account for up to 70%-90% of all lightning.
3. The third most common type of lightning is ***cloud to air*** lightning that occurs when the air around a positively charged cloud top reaches out to the negatively charged atmosphere around it.



4. The fourth most common type of lightning is the most well-known, ***cloud to ground***, and primarily originates in the thundercloud and terminates on an earth surface. Anywhere from 10-30% of lightning can be cloud to ground, depending on the storm. Of the four primary types of lightning, it poses the greatest threat to life and property since it terminates at, or strikes, the earth.

Not all lightning forms in the negatively charged (the lower area) of the thunderstorm cloud. Some lightning originates at the top of the thunderstorm, the area carrying a large positive charge. Lightning from this area is called positive lightning. Positive lightning is particularly dangerous because it frequently strikes away from the rain core, usually ahead of the thunderstorm. It can strike as far as 5 or 10 miles (8 or 16 kilometers) from the storm in areas that most people do not consider to be a lightning-risk area. This is why most lightning strikes happen prior to a storm.



Types of Injuries from Lightning

Injury from lightning can occur by several mechanisms:

Ground current*:* When a lightning strike hits the ground, the electricity does not disappear into the earth. It spreads out in the ground as a potentially deadly current with voltages decreasing from the point of the strike. These currents are lightning's biggest danger because they affect large areas in circles, extending out from where lightning reached the ground, such as at the bottom of a tree. If a person happens to be standing in a place affected by a ground current, it can travel up one leg, through the body (and potentially stopping the heart and breathing), and then down the other leg.

***Side splash**:* This refers to lightning that jumps from an object to a person, or even from one person to another. Side splash occurs because lightning follows the path with the least electrical current resistance to the ground.

***Upward streamer**:* The third most common cause of lightning deaths and injuries are the upward leaders, also called "streamers," that rise from high objects and the ground just prior to lightning strikes.

***Direct strike**:* Lightning that hits someone directly from the sky is called a direct strike. This rarely happens.

***Contact**:* It is well known that lightning when it strikes a building can get into the wiring or the water pipes and kill someone talking on a phone with a cord or someone taking a shower. This does happen, but such "contact strikes" are as rare as direct strikes.

Deaths Due to Lightning by Type	
Ground current	50-55%
Side splash	30-35%
Upward streamer	10-15%
Contact	3-5%
Direct strike	3-5%

***Blunt Trauma**:* This occurs from the impact of the concussive force of the strike itself or from being thrown due to the extreme nature of the muscular contraction from the electrical charge. Blunt Trauma is responsible for most of the lightning injuries.

Treatment for Lightning Strikes

The most common cause of death in lightning strikes is a cardiopulmonary arrest. This condition results from both the direct current to the heart and paralysis of the respiratory center in the brain. Persons who have been hit by lightning and are in respiratory arrest may need only artificial respiration to prevent the secondary hypoxic arrest. Almost all persons hit by lightning who do not have cardiac and/or respiratory arrest at the scene survive, even though they may be seriously injured. If multiple persons are struck by lightning, triage priorities must be reversed. This is called reverse-triage. Those in cardiac and/or respiratory arrest appear dead but must be treated first. Persons struck by lightning have a better chance of survival than persons who experience cardiopulmonary arrest from other causes. Resuscitation for persons struck by lightning must be initiated immediately.

Immediate cardiac arrest from a lightning strike results from direct current depolarization of the myocardium of the heart. Immediate respiratory arrest after a lightning strike is a result of paralysis of the medullary respiratory center. Although cardiac rhythm may spontaneously return, concomitant respiratory arrest may persist and lead to a secondary hypoxic cardiac stoppage. The duration of apnea, rather than the duration of cardiac arrest, appears to be the critical prognostic factor. Some other important lightning information is that victims of lightning do not retain the charge and are not "electrified." It is safe to help them.

Pathophysiology Effects from a Lightning Strike

In addition to flowing on the outside of the body (flashover), the electrical current may also enter the body through the cranial orifices (eyes, ears, nose, and mouth) and flow through the body. This

may explain why some patients have certain injuries such as ocular and/or ear, and others do not. Although the current flow occurs over a very short period of time, the amount of current is huge with an amazing amount of energy.

Damage to the ***central nervous system*** is the second most debilitating group of lightning injuries. Neurologic complications include immediate loss of consciousness, amnesia and confusion, retrograde amnesia, hemiplegia, aphasia, coma, and seizures.

Eye complications are also common and include cataracts, macular holes, corneal lesions, hyphema, iritis, retinal detachment, and injury to the optic nerve.

Hearing complications are frequent. People struck by lightning often have a ruptured tympanic membrane, temporary hearing loss, dizziness from eighth nerve damage, and injury to the hearing bones.

Other common complications of being struck by lightning include chronic pain syndrome and neuromuscular pain. Many people develop neurocognitive deficits, including short-term memory loss, difficulty accessing or processing new information, attention deficit, personality change, distractibility, or loss of ability to multitask. Many develop depression and the feeling of isolation. Sympathetic nervous system dysfunction is seen including positive tilt tests and hypertension. People frequently report dizziness and sleep disorders. Symptoms similar to post-concussion syndrome (e.g., headaches, nausea, and confusion) are seen. People develop an atypical seizure disorder. Endocrine problems can develop, including pituitary or hypothalamic damage with secondary endocrine effects. These symptoms can start right after the strike or often appear weeks to months later and can persist for years.

Few individuals experience the full energy of a lightning strike because only about 3-5% of injuries are from a direct strike. Most of the energy is transmitted by other objects that are hit, such as the ground or a tree. Fewer than half of affected persons have signs of burns or any other marks. There are only about 20 cases reported of lightning strikes to pregnant women. The maternal outcome is generally good.

The identification of a victim of a lightning strike is easy if the strike was witnessed. However, there may be situations where it is unclear. Lightning injuries must be suspected when in the outdoors and in weather conditions conducive to lightning. Always follow the MARCH protocol. Call for evacuation to the closest medical facility. Any patient who is a victim of a lightning strike should be evacuated as soon as possible.

Reduce Risk

"When thunder roars go indoors." If you hear thunder, then you should seek shelter. This is based on the fact that the distances that sound travels are well within the distance of a lightning strike. Furthermore, you may miss lightning because the clouds or other terrain hide it. There is no safe place outdoors.

There is little you can do to substantially reduce your risk if you are outside in a thunderstorm. The only completely safe action is to get inside a safe building or vehicle. However, some people in the wilderness sometimes find themselves exposed, far from shelter. If you absolutely cannot get to safety, you can *slightly* lessen the threat of being struck with the following tips. But, don't be

deceived--you are **NOT** safe outside. Know the weather patterns of the area you plan to visit. For example, in mountainous areas, thunderstorms typically develop in the early afternoon, so plan to hike early in the day and be down the mountain by noon. Find the weather forecast for the outdoor area you plan to visit. The forecast may be very different from the one near your home.

If you are in the wilderness, and thunderstorm develops, these tips can ***slightly*** lessen the threat of being struck by lightning:

- Avoid open fields, the top of a hill, or a ridge top.
- Crouched positions offer little protection.
- Stay away from tall, isolated trees or other tall objects.
- If you are in a forest, stay near a lower stand of trees.
- If you are in a group, spread out to avoid the current traveling between group members.
- If you are camping in an open area, set up camp in a valley, ravine, or other low areas.
- Remember, a tent offers NO protection from lightning.
- Stay away from water, wet items such as ropes, and metal objects such as fences and poles. Water and metal do not attract lightning, but they are excellent conductors of electricity. The current from a lightning flash will easily travel for long distances.

Unless specifically designed to be lightning safe, small structures do little, if anything, to protect occupants from lightning. Many small open shelters on athletic fields, golf courses, in parks, at roadside picnic areas, in schoolyards, and elsewhere are designed to protect people from rain and sun, but not lightning. A house or other substantial building offers the best protection from lightning. However, people should stay away from windows and doors, and avoid contact with anything that conducts electricity, such as landline telephones.

Cars provide good protection. Lightning flows around the outside of a car, and the majority of the current flows from the car's metal cage into the ground below. It is not the rubber tires that protect you. In essence, a car acts like a mobile Faraday cage. (A Faraday cage is an enclosure formed by conductive material used to block electric fields.) Convertibles do not have metal roofs, which compromises the Faraday cage effect

The best rule is that if you see lightning or hear thunder go indoors. The threat of lightning continues for a much longer period than most people realize. Wait at least 30 minutes after the last clap of thunder before leaving shelter. And remember, don't be fooled by sunshine or blue sky.

CLICK HERE
to take a practice EXAM on Lightning

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to listen to a PODCAST on Lightning

Chapter 3: Clothing for the Backcountry

Clothing might seem like an afterthought when one is headed outdoors or planning for an adventure. Still, it's the first and most important layer of protection between you and the elements. No level of skill or planning can make up for ill-chosen clothing if the weather takes a turn for the worse. It's essential to understand the fundamentals of layering to make sure you can stay safe in any conditions.

UNDERSTANDING CLOTHING AND HEAT

Heat from our Bodies

To understand the use of clothing, it is first essential to understand heat. In simple terms, heat is energy. The more energy there is in a system, the more heat there is in a system. Temperature is a measure of heat. There is no such thing as 'cold.' When something is cold, there is less energy or less heat.

Another important fact to know is that the human body is only about 10-25% efficient in processing the food that we eat into energy. All of the unused energy is given off as heat. That heat is always leaving our bodies. The normal human body temperature is averaged at around 98.6°F (37°C). Since the air around us is usually much cooler, heat is always leaving our bodies. All we can do is control the heat flow as it leaves our bodies. If the body can't divest the excess heat, the human core temperature raised above the average temperature, and we become very hot. That is known as ***hyperthermia***. If we give off heat too quickly, then the body temperature drops, and we become very cold. This is known as ***hypothermia***. Clothing is designed to control how much, and how quickly, heat can leave the body.

Body heat is given off three (3) ways:

Radiation

Radiation is how most heat leaves the body. Heat loss by radiation is continuously occurring during the winter months when temperatures fall significantly below this threshold.

Conduction

Conduction occurs when the body is in contact with any object that is cooler than the body. Heat loss by conduction can be a significant issue when in contact with snow, ice, or cold water.

Convection

Convection occurs when the heat is transferred away from the body through circulating air currents. This is like sitting in front of a fan, and it's why we feel cooler when the wind is blowing. Heat loss by convection can be significant during winter storms with exposure to the wind.

Note: ***Evaporation*** is the process that occurs when you sweat. It utilizes all three methods of heat transfer and is not a separate method.

It is crucial to keep in mind the different ways that heat is lost from the body to understand clothing. Heat moves from hot temperatures to cool temperatures. No heat can be transferred when two objects are at the same temperature. When air temperatures rise, radiation no longer

works, and the body relies on convection and conduction. Water (sweat) is poured onto the skin to facilitate heat loss by wind and conduction. When the air temperature becomes the same as the body temperature, then no heat can be lost from the body, and the body temperature will start to rise dramatically. Hypothermia occurs if a body loses heat too much and too fast.

When it is cold, we bundle up to keep heat in, and when it is hot, we take clothes off to allow more heat to leave our bodies. One of the most excellent conductors of heat is water. One of the poorest conductors of heat is air. For example, in the summer, when we want to conduct heat out of our bodies, we go swimming. If we want to keep heat in our bodies, we will surround ourselves with air. Fibers and fabrics, such as wool, are excellent insulators because they have a lot of air in them. Since water is a good conductor of heat, the inside layers of clothing are designed to move or 'wick', water away from the skin.

Layering

Heat transfer out of the body is best controlled with clothing worn in layers. Body heat is trapped in the dead air space in the middle layer creating insulation, while perspiration is wicked away from the skin and through to the outer layer to prevent conductive losses. Wind and rain cannot penetrate the outer layer, therefore limiting convective heat loss. Not all clothing is designed to insulate.

Base layer

This is the layer of clothing directly against your skin, and its purpose is to wick sweat away to keep you dry. This includes socks, underwear, and an initial pant/shirt base layer if in colder conditions.

Middle layer

The middle layer is for insulating. This layer functions to retain body heat by creating 'dead air.' This can be clothing such as shirts and pants, thus an extension of the wicking layer.

The Outer layer

The outer layer, or shell, is a water- or wind-resistant barrier between you and the elements, keeping the wind from blowing across someone and causing convection loss of heat.

If you don't plan on wearing these three layers throughout your trek, it would be prudent to at least pack these types of layers to have just in case. The benefit of the layering system is flexibility. If conditions change, you can always peel off layers to cool down or add layers if the weather takes a colder turn. However, if you don't pack those essentials, you might be left out in the cold.

Some clothing will help move heat away from the body. For example, in hot environments, loose-fitting clothing should be worn to move heat away from the body, as this facilitates ventilation.

Types of Fabric

What types of fabric are more appropriate to wick water from the skin, insulate from heat, or even facilitate heat loss? This topic has been discussed by recreationists of all experience levels. It can take some experimentation to figure out what works best for you. Here are some basic guidelines to consider when choosing the fabric that best fits your activity and goals:

Wool

Wool is a very popular choice and with good reason. Wools 3D wavy crimp-type fibers trap air easily. Eighty percent of the material is air. It's an excellent insulator and will keep body heat contained in cold weather. Wool also absorbs a lot of water. For example, merino wool is capable of holding 30% of its weight in water absorption before the wearer can even feel it on their skin. Even with the water that it has absorbed, the wool maintains insulation, which is a huge plus for this material. Wool is also wind resistant. These properties make it an ideal fabric choice for most activities. Many people use wools as their base layer. Once maligned for being itchy, ultra-fine merino wool is itch-free, naturally breathable, moisture-wicking, fairly fast-drying, and not prone to odors.

Polyester and Nylon

Polyester and Nylon are synthetics, such as fleece, that offer quick-drying capabilities at a more affordable cost. These fabrics are quite durable and make great slacks and shirts. Synthetic fibers have 3D patterns that imitate wool. Synthetics are warm when wet, but do not absorb moisture. They dry quickly, are as warm as wool, and are only half the weight of wool. One problem is that synthetics have poor wind resistance. They can also develop an odor worse than wool. Overall, however, synthetics are a fantastic and affordable option that many choose as their base layers.

Down

"Down" is the under plumage that is found beneath the feathers of ducks, geese, and other waterfowl. It is natural insulation. Goose down insulation itself does not consist of feathers. Goose down frequently contains terms like "600+ fill goose down" or "900+ fill goose down" lines. These numbers indicate how much goose down is actually added to the coat or sleeping bag, for example. This is known as the "fill rating." The higher the number, the more goose down insulation is added into the coat or sleeping bag, and the warmer it should be.

Down is very soft, provides excellent insulation, and is very lightweight. It must be packed in compartments for this reason. It is excellent to use for sleeping bags and coats as it packs well, and it conforms to the user. The problem with down is that it will clump when it is wet and lose its ability to create dead air space, thus losing its insulative ability.

Silk

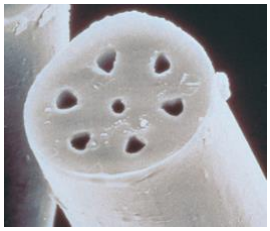
Silk is a soft, luxurious fabric that is quite thin and light, making it a great choice for moderate, cool-weather conditions. The downside is that it doesn't wick moisture away from the skin as well as

wool or synthetics, so it isn't a good option for warmer days or activities with a great deal of exertion. Another consideration of silk is that, like synthetics, it can be prone to odor. The softness of silk also results in it being a less durable fabric, and its vulnerability to abrasion and sunlight results in a shorter lifespan than the other fabrics discussed.

Cotton

Cotton is never a good choice for outdoor activities, even when layering. There's a reason that experienced recreationists use the phrase "cotton kills." Cotton does not effectively wick moisture away from your skin, it doesn't dry quickly, and it is a very poor insulator. While wool will keep you warm when you're wet, cotton will keep you cold when you're wet. Even cotton socks should be avoided, as wet and cold feet are a recipe for disaster. So, in reality, cotton does not kill, but hypothermia does. It's easier to get hypothermia when you wear cotton, not because it doesn't insulate you as well as other materials, but because it just doesn't insulate you as well when it is wet. Cotton is a comfortable and cheap option for lounging around at the campsite but should be avoided for active pursuits.

Synthetic Fibers



Synthetic fabrics are human-made and produced entirely from chemicals to create fabrics like polyester, rayon, acrylic, and many others. Natural materials, such as cotton, silk, and wool, are made of animal and plant-based fibers.

Over the years, synthetic fibers have increasingly grown in popularity. They are resistant to insects and fungus and have little to no ability to absorb moisture. Synthetics can easily create dead space. And because they are usually cheaper to produce, they are cheaper to buy.

A serious drawback of synthetic fibers is that they will melt. Since they have little to no ability to absorb water, they will always insulate, even when wet. This makes synthetic clothing ideal in wet environments like river trips. However, synthetic clothes are heavy and do not pack well, so they are not suggested for hiking.

Microchannels can be created in the fibers to create **Quallofil** and **PolarGuard**. Quallofil is made by Du Pont and is used both in sleeping bags and in many insulated jackets. The problem with Quallofil is that it is a bit on the heavy and bulky side. Polarguard, and all its various derivatives, is considered the "premiere" synthetic insulation and is used in most high-quality synthetic sleeping bags and clothing. New iterations have made the material significantly less bulky, while at the same time improving the insulating abilities by around 10%.

Super thin fibers are a small synthetic fiber. They are very tiny, so manufacturers can put more of these in clothing. That means dead air space and more insulation. Since they are small, they are also light and pack well. They stay dry and keep their warmth when wet. There are not too many negatives with this material. Primaloft and Thinsulate are examples.

Tying it all Together

Now that you've learned about the basics of layering, fabric types, and sun protection, it's time to bring it all together. We've discussed the three main layers (sweat-wicking, insulating, shell) and three optimal fabrics (wool, synthetic, silk), but how do you combine those?

The Base layer (wicking). This layer needs to be one of the high-performance fabrics, such as wool, synthetic, or silk. Its purpose is to wick sweat away to keep you dry. Many consider this to be the most important layer of all, as this is the layer that keeps you cool and comfortable when you're working up a sweat. The weight of this base layer can also change depending on the season and activity. Examples of wicking layers are Capilene, Lifa, and Dryline

The Middle layer (insulating). The middle layer functions to retain body heat. This is the layer that will keep you warm and is typically the thickest or heaviest-weight material of the three. Wool and down are popular choices for mid-layers, but you can also choose fleece or synthetics with high-loft options such as Polar-guard, Micro-loft, and Primaloft. For wet weather, it would be wise to choose those synthetic pile or fleece options, as down can get soggy and lose its insulating capabilities in very wet conditions. Synthetics are also breathable and easier to ventilate and wash. A good rule of thumb for the mid-layer in colder weather would be to plan on wearing a synthetic as your go-to and to always pack an extra down jacket. Down "puffies" are easily compressible and lightweight, so they add substantial function at a low weight.

The Outer layer (shell). The outer layer is a water- or wind-resistant barrier between you and the elements. Being the first line of defense against the elements, this layer needs to be able to repel rain and snow while simultaneously being breathable. You don't want your perspiration to build up inside your layers; that would defeat the purpose altogether. In very wet conditions, go for something completely waterproof, with features like sealed seams, zipper guards, and cinch-able hoods. Things like armpit zips and mesh pockets can help you ventilate even while working up a sweat in wet conditions. In drier conditions, you can consider using a lighter shell that is just windproof. These typically aren't very waterproof but are highly breathable, and pack down small enough to fit into a pack.

Now that you know the essentials of dressing for the outdoors, you can simply mix and match your layers to prepare appropriately for any conditions. Remember that what you wear is what is keeping you safe against whatever mother nature throws at you. There is no bad weather, only bad clothing.

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to take a practice EXAM on Clothing

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Chapter 4: Backpacks, Trekking Poles and Back Pain

Overloaded and improper wearing of backpacks lead to unnecessary medical problems
in the spine. While there is abundant evidence that backpacks can cause short-term problems, it's unclear whether they may cause permanent orthopedic conditions such scoliosis or long-term damage to still-developing skeletons. Never-the-less, outdoor adventures can do simple things to help prevent back and other joint pain while enjoying the back country.

The Science of Backpacking and Back Pain

The weight of a backpack and how it is worn play a huge role in preventing pain. However, a study published in the June 2016 issue of *The Spine Journal*, found that how long a bag was carried had a significant impact on back pain, even more than the weight that was carried. This contradicts many long-held beliefs that the weight of the backpack was the primary driver of pain. The key takeaway to this study is if you don't need to carry your backpack, put it down. Wear it only when you're traveling from one location to another. Mindlessly wearing your backpack could end up causing you pain. But this does not mean that weight of the back pack is not a problem-it does. Also, just how that weight is worn matters. To protect your back from pain, here are some key points.

Choosing the Right Bag — Torso Length

Make sure that the backpack is the right size for the torso. To do this, determine the torso length — the distance from the 7th cervical vertebra (C7) down to the top of the iliac crest along the spine. Use that torso length to choose a backpack size

Torso length	**Backpack size**
15–17 inches	XS backpack
16–19 inches	S backpack
18–21 inches	M backpack
20–23 inches	L backpack

Once you have the right pack, you'll need to know how to properly adjust all those straps to optimize comfort and support. You should do this every time you put the backpack on after you've modified the strap length. If you're just testing out a backpack and adjusting the straps, the backpack should be weighted down to properly simulate how it would feel in the field. Start with all the straps fairly loose and go through these steps in order:

Waist belt — The weight of the backpack should be on the waist. The back is not really designed to hold so much extra weight, but the legs are. Buckle the waist belt and adjust the position so that the padding rests on top of the iliac crest of the hip bones. Adjust the shoulder straps to get the proper height. Tighten/loosen the waist belt so that it fits snugly but doesn't pinch you. It should be secure but comfortable. One way to make sure the waist belt is on top of your hips is **to shrug your shoulders** while wearing the backpack. While shrugging, tighten the waist belt so that it's snug. Then release your shoulders. The backpack should come down on top of your hips.

Shoulder straps — Tighten the shoulder straps so that the straps wrap and hug your shoulders and upper back closely but doesn't pinch your armpits. The shoulder straps should attach to the backpack a couple inches below the top of your shoulders. If there is too much space between your shoulders and the shoulder straps, or if the anchor point of the shoulder straps is to high or low, the backpack may be the wrong size or the torso length needs to be adjusted.

Load-lifter straps — Tighten the load-lifter straps to bring the upper part of the backpack a bit closer to your back. This will decrease the torque that the back will cause.

Sternum strap — Lastly, put on the sternum strap. The sternum strap height should be about an inch below your collarbone. Its purpose is to relieve the stress on your shoulders by pulling the shoulder straps slightly closer together and should allow your arms to move freely, and to keep the shoulder straps from slipping out of place.

Remember that backpacks shift the center of gravity backward a bit, so **leaning forward slightly** will help you keep balance as you trek. If you feel your shoulders getting overly exhausted**, shift more weight onto the waist belt** (tighten slightly) and loosen the shoulder straps slightly).

Trekking poles

Trekking poles are basically 'ski poles' that are specifically designed for use while hiking. Some studies have shown that hiking poles can help to prevent back pain. Research has also shown that using poles helps alleviate the pressure placed on other joints such as the knees and hip. However, it is not clear if this prevents long term sequelae. It is also not known if poles help people from falling or tripping. But, there is a lot of subjective data on this. Some people simply find that they are more stable, especially on steep uphill and downhill slopes while using trekking poles. In particular, people with balance issues and people who are new to hiking find that trekking poles give them the confidence they

need to get out and enjoy the world. Whether or not trekking poles actually improve one's balance or just give people the mental fortitude to take on slick or steep slopes is a matter of personal opinion. But for many people, trekking poles are crucial to their ability to travel over difficult terrain. Additionally, hiking in places where the hiker needs to cross a lot of streams will find that trekking poles can be really helpful. If you've ever slipped off of a rock that you were perilously trying to balance on while crossing a stream, you know that it can sometimes be difficult to get to the other side without trekking poles.

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Chapter 5: Wilderness First Aid Kits

A frequent and relevant question asked in wilderness medicine is the type of first aid kit one should bring on a trip. It depends! This chapter covers helpful guidelines to assist us in choosing the appropriate items for that planned trip.

General Guidelines

General guidelines include asking yourself several questions to identify important aspects of your trip, such as:

- What type of activity or sport will your group engage in on this trip?
- How long is the trip going to be?
- How big is the group?
- Is this a group kit or your own individual kit?
- How far are you from help, and how easy will it be to evacuate if needed?
- What diseases are endemic to the area you're going to?
- What are the diseases and known conditions of the participants who are going?
- How far away from definitive care will you be on your trip?
    - For example, a backpacking trip of seven days over high, mountainous terrain far from civilization requires a medical kit that is lightweight and contains items that can treat emergencies related to high-altitude illness, cold exposure, trauma, geographically specific infectious diseases, and avalanches.
    - In contrast, a one-day river trip near a highway where weight is less of an issue and evacuation may be aided by a nearby vehicle would be entirely different. You would want items to treat emergencies related to water sports, cold exposure, and trauma.

Pre-Made Medical Kits

Premade medical kits are filled with items to cover general cuts and scrapes. They are not specific enough to cover a broad array of injuries. First aid kits tend to emphasize treatment, but they also deal with prevention items, such as water treatment material and gloves. First aid kits should emphasize improvisation and multiple uses. For example, duct tape can be used for numerous issues rather than one specific issue. If you are aware of the medical condition of the participants and recognize endemic or common diseases in the area, you can take the appropriate medicines with you.

Containers

Containers for first aid kits will vary along with the contents. For example, a six-day trek over mountainous terrain far from cities will require a medical kit that is lightweight and contains items that can treat emergencies related to high-altitude illness, cold exposure, trauma, and geographically specific infectious diseases. A three-day river trip with four young, healthy people can be in a metal container, it can be more substantial, and can contain items to treat abrasions as well as items for a twisted ankle and splints.

Many commercial kits are available and carry essential supplies and equipment but do not contain prescription medications. Making your own kit is an option and can save money. Either way, you will need to adjust and bring items that pertain to the specific activities and location planned.

PAWS

Though it's not practical to list each item that should go in every type of medical kit, some general items are helpful to have. The acronym PAWS is an excellent way to remember the category of items to include in a first aid kit.

P	Prevention / Procedures
A	Analgesics / Antibacterials / Antiseptics
W	Wound care
S	Survival

Prevention/Procedures

Prevention

These are items for the prevention of illness and potential problems:

- Water filter and water purification tablets
- Gloves
- Sunscreen/lip balm
- Sunglasses
- Blister prevention and treatment
- Insect repellant and barriers (netting / treated clothes)

Procedures

There are specific tools of your trade that may be used in a variety of situations:

- Wound care material: steri-strips, tape, gauze, Medi-honey, sutures, etc.
- Scissors
- Dental repair material: Cavit, eugenol, etc.
- Blood pressure cuff and stethoscope
- Flashlight
- Syringe
- Flexible splints
- Safety pins
- Needles
- Tweezers

Analgesics, Antibiotics, Anaphylaxis

There should be medicine available in each kit that covers pain and infection that could be encountered. You should know what diseases are common in the area you're headed. As well, you should know the diseases and chronic conditions of the people traveling in your group.

Analgesics

Tylenol (also called Paracemetol and Acetaminophen) belongs to a class of drugs that relieves pain and lowers fevers. It does not prevent the clotting of blood, so it is safe to use in head injuries.

Aspirin prevents blood from clotting, which promotes bleeding. Therefore, it should not be used in any kind of head injury. Aspirin, also known as acetylsalicylic acid (ASA), is a medication used to treat pain, fever, and inflammation.

Ibuprofen is used to relieve pain from various conditions such as headache, dental pain, menstrual cramps, muscle aches, or arthritis. It is also used to reduce fever and to relieve minor aches and pain due to the common cold or flu. Ibuprofen is a nonsteroidal anti-inflammatory drug (NSAID). It works by blocking your body's production of certain natural substances that cause inflammation. This effect helps to decrease swelling, pain, or fever.

Antibiotics

Select antibiotics that cover a broad spectrum of pathogens. Here are some common broad-spectrum antibiotics to consider taking:

- Doxycycline: lung, skin, and tick/mosquito-borne infections
- Cipro: HEENT, enteric, lung, skin, and urinary infections
- Amoxicillin /clavulanic acid: HEENT, lung, skin, enteric
- Azithromycin: HEENT, lung, skin, enteric organisms

Anaphylaxis

Anaphylaxis is one of the true medical emergencies that one may see in the wilderness. You should always be prepared to treat an anaphylactic patient.

- EpiPen®
- antihistamines
- albuterol inhaler
- oral steroids
- Ranitidine

Wound Care

Regardless of the activity, abrasions and lacerations are among the most commonly experienced injuries. As a result, appropriate and adequate supplies for wound care are one of the essential parts of a medical kit. Having each person on the trip bring their own necessary wound supplies will help to ensure that enough wound care supplies are available. Below are different treatment options for primary wound care:

- Gloves
- Alcohol swabs, antiseptic wipes

- Gauze
- Steri-strips, benzoin
- Tape
- Ace bandages
- Irrigation equipment
- Band-aids
- Antibiotic ointment, Medihoney
- Gauze wrap
- Q-tips

Survival

The potential for the group members to be separated, and other worst-case scenarios need to be considered. Below is a list of items each group member should carry at all times.

- Map, compass, knife, fire starter, matches
- Communication equipment: satellite phones
- Space blanket
- Knives

Other Helpful Suggestions

The Centers for Disease Control (CDC)

The CDC website (www.cdc.gov) provides information for the preparation of a first aid kit for any location in the world. The information provided includes a list of antibiotics, items for a first aid kit that is specific to that area, and a list of other medicines important to have. It also talks about diseases endemic to that area and any required vaccinations. Look at 'Traveler's Health' and follow the links to first aid kits and medicines. Their information is current and up to date on the latest medical and health issues worldwide.

Documentation

Materials such as a pen and paper are an essential part of a first aid kit, though they are often left out. A pen and paper can be used to document illnesses and injuries. Write down essential data and document important facts. Instructions can be written down, and a history of what aid was rendered can be memorialized.

Expiration Dates

Check the medicines in your first aid kit often to see if their effectiveness has expired. The expiration date addresses medicine's highest effectiveness. It's a gauge of how close to its optimal efficiency a drug will function. That date is based on several factors, including how well the drug worked when it was tested and then sealed in its unopened container, and whether it was maintained at certain temperatures and moisture levels. Once the drug is opened, its expiration date isn't as useful to gauge its effectiveness. Typically, medicines will change into a brownish color

when they lose effectiveness. However, EpiPens are airtight. Experts think the expiration date is a good gauge of the injectable drug's highest potency.

Cleaning a Wound

You don't need any special liquid to clean a wound. Water is very effective. Due to its ability to kill bacteria, people have used hydrogen peroxide, iodine, and alcohol in the past. However, plain water with vigorous irrigation works just as well. Using alcohol and full-strength hydrogen peroxide can damage vital tissues. If a wound is significantly contaminated, and a person is immune-compromised, diluted hydrogen peroxide can be used. Hibiclens is a gentle cleaner but has shown to be about the same as cleaning with plain water. Iodine, in the form of betadine, is an appropriate antimicrobial for possible use if a wound is highly contaminated. Betadine is an excellent choice for your kit.

Honey

Honey has been used to treat wounds and speed healing as far back as ancient Egypt. Its use faded in modern times as a plethora of antibiotics were developed to treat infections. Honey is now making a resurgence as more bacteria strains develop resistance to overused antibiotic ointment.

So far, bacteria have not been able to develop a lasting resistance to honey. Honey has a wide variety of wound healing, and its antibacterial properties are recognized by the medical community. There are several preparations that have been formulated for medical use in the treatment of diabetic foot ulcers, leg ulcers, pressure sores, first and second-degree burns, and other cuts and scrapes. One of the most attractive attributes for honey as a wound treatment is its ability to fight off Methicillin-resistant Staphylococcus aureus (MRSA) and other resistant strains of bacteria where other antibiotics have failed. Ointments with sulfa, polymyxin B and neomycin as their base are good but are not recommended. There are high allergic rates to some of these ointments, which would be problematic on a back-country trek.

Hypoglycemia/Diabetes

Any time you plan to head into the backcountry with a diabetic person, insulin becomes an important component of your first aid kit. Newer insulins can be kept at room temperature, though they are best kept cool. Backcountry temperatures can be hot, and the temperature in first aid kits can rise beyond air temperature. It's essential to keep insulin cool, along with other types of medicine.

It's important to put a glucose source such as a piece of candy or some jelly in your first-aid kit, especially if the outdoor activity is physically demanding. Hypoglycemia occurs when a diabetic's blood sugar drops so low that the brain is starved of sugar. Unconsciousness will follow, and then possibly death.

Closing a Wound

Multiple modalities for closing a wound are appropriate. The type of wound, the type of outdoor activity and the ability of the provider to use the medical items all play a role in selecting what to bring. The primary goal of wound closure is to bring the wound edges together in order to improve the functional status of the victim. Suturing a wound requires the most skill. If you are comfortable with this and have the training, suturing a wound is appropriate. Sutures need to be removed after a period as they may increase the possibility of infection. Steri-strips are easy to use but have

problems sticking. If the wound is bloody or becomes wet from water or sweat, the steri-strip(s) may come off. Skin glue is appropriate in some situations. If the wound is already approximated and not bleeding very much, then skin glue is appropriate. It's is meant for small wounds

A common misconception regarding wounds is that closure of the wound decreases the chance of infection. However, closure of the wound may increase the likelihood of infection compared to packing the wound and dressing it appropriately. An important consideration is that there is generally no increase in scarring if one packs and dresses a wound and then closes it three-to-five days later, as opposed to closing it at the time of injury. Packing and dressing a wound with delayed closure is termed delayed primary closure. If one is in the wilderness for a period of five days or less, then delayed primary closure is a good option.

Additional Items to Consider

Other items for potential inclusion depending on the nature of your trip and your group:

- Equipment
- Pocket medical reference on paper or electronic
- Finger and toenail clippers
- Sewing kit
- Alcohol-based hand sanitizer
- Digital thermometer (expanded range for hyper/hypothermia)
- Urine pregnancy test
- Stethoscope
- Pulse oximeter

Medications

- Oxymetazoline (nose spray for nose bleeds)
- Silver nitrate cautery sticks
- Hemorrhoid ointment
- Albuterol
- Sting ointment

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Chapter 6: Foot Problems in the Backcountry

Foot problems that occur in the backcountry can quickly become a much bigger issue. It is estimated that over 90% of hikers have experienced painful foot issues. Depending on how long the foot problem lasts, it can have an impact on a person's ability to continue their backcountry experience.

From a medical perspective, it is challenging to assess these types of patients because of the complexity and multiplicity of joints within the foot. There are 28 bones in each foot, which is nearly one-fourth of all the bones in the entire body. As well, there are 30 joints and more than 100 muscles, ligaments, and tendons. These make the feet flexible so that they can adapt to uneven surfaces, but it becomes complicated when there's an injury.

ANATOMY OF THE FOOT

Foot Structure

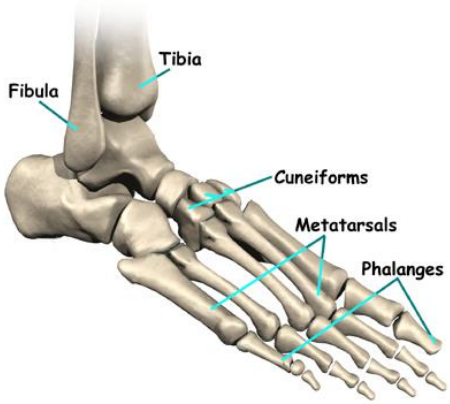
The foot is divided into three sections:

- Forefoot
- Midfoot
- Hindfoot

There are bones, joints, muscles, tendons, and ligaments in each section.

Forefoot

This is the very front part of the foot, including the toes, or phalanges. The first metatarsal bone is the shortest and thickest and plays an essential role during propulsion. It is a common bone to injure in backcountry hiking (the big toe).



Toes (Phalanges)

The toe function is to grip, clamping the feet to the walking surface. They give final propulsion as the foot completes a step, shifting weight to the other foot. Although the big toe carries part of the bodyweight with each step, no weight rests on the big toe as the body stands. The toes' gripping tendency helps to maintain balance and aid in propulsion.

Midfoot

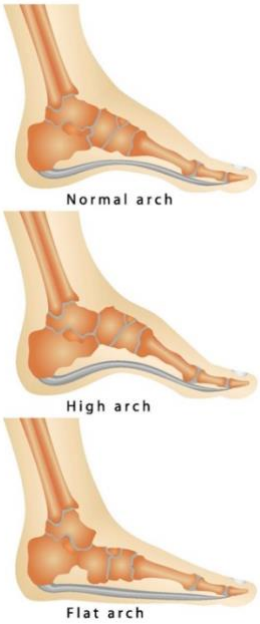
This section of the foot is made up of five irregularly shaped bones called the tarsals. The clinical names for these bones are the navicular, cuboid, and medial, intermediate, and lateral cuneiforms. Together they form the arch of the foot. The arch of the foot plays a key role in weight-bearing and stability.

Hindfoot

There are only two large bones in this section of the foot: the ***talus*** and the ***calcaneus***. The largest of these, the calcaneus, forms the heel of the foot. The talus rests on top of the calcaneus and forms the pivoting joint of the ankle.

Arches

The foot has three arches: two longitudinal (medial and lateral) arches and one anterior transverse arch. Arches are designed to act like springs, aid in propulsion, and store energy. The arches shape is designed in a similar manner to a spring, and bears the weight of the body and absorbs the shock that is produced with locomotion. The foot's flexibility, conferred by the arches, is what facilitates everyday loco-motor functions such as walking and sprinting. The energy-sparing spring properties of the foot's arch have become central to the foot's mechanical function. The metabolic energy saved by the arch is due to the passive-elastic work it supplies that would otherwise be done by active muscles.



Muscles

The muscles that control the movements of the foot originate in the lower leg and are attached to the bones in the foot with tendons. These muscles and tendons are the sites for overuse syndromes.

Tendons and Ligaments

The most important tendon of the foot is the Achilles tendon, which runs from the calf muscle to the heel. It is the strongest and largest, tendinous structure in the body. [2]The Achilles tendon makes it possible to run, jump, climb, hike, and stand on your toes. The clinically significant ligaments of the foot are the:

- **Plantar fascia:** The longest ligament of the foot, the plantar fascia runs along the sole of the foot from the heel to the toes to form the arch of the foot, to provide strength for walking, and to assist with balance.
- **Plantar calcaneonavicular ligament:** This is a ligament within the sole that connects the calcaneus and the navicular, and supports the head of the talus.
- **Calcaneocuboid ligament:** This is the ligament that connects the calcaneus and the tarsal bones, and helps the plantar fascia support the arch of the foot.

Protecting Your Feet for Wilderness Activity

'Prevention is worth a pound of cure.' This is so true with shoes. Here is what you need to know to prevent foot problems in the wilderness.

Arch Supports

This becomes an essential issue in backcountry medicine, especially with hikers and trekkers, because they typically carry an additional load on their back. A person with a low longitudinal arch, or flat feet, often stands and walks with their feet in a pronated position, where the foot everts. This makes the person susceptible to heel pain, arch pain, and plantar fasciitis.

With high arches, there is less surface area for absorbing impact. This places excessive pressure on the back part of the foot and the forefoot areas. This can make a person susceptible to foot conditions such as heel pain, metatarsalgia, and plantar fasciitis. Having proper arch support becomes vital in making the backcountry trip successful. Most shoes have useless inserts, rather than arch supports. These should be removed, and arch supports placed inside. If people really need new shoes but cannot afford them, arch supports are a less expensive alternative and offer significant help.

A Perfect Shoe Story

A 38-year-old woman was preparing for the Boston Marathon, running many miles each day. As the marathon drew nearer, and she continued with her training, her knees began to hurt and swell. One week before the race, she went to her doctors for the pain and swelling. The physician examined knees, finding arthritis in them. Then he studied her shoes and found out that they were over 5-years-old and had no support at all. With this realization, the woman bought running shoes with proper support. Her impact arthritis resolved quickly, and she was able to run the Boston Marathon, a significant achievement.

There is probably nothing more important for foot care than having proper shoes that fit appropriately. Shoes are definitely activity-specific. When it comes to exercising and sports, gym sneakers are not a one-size-fits-all solution.

There is a lot of technology that goes into the design of shoes. Each activity has specific qualities necessary for the correct footwear. Running and walking shoes are made for straight-ahead, forward motion, while basketball and tennis shoes are made for side-to-side movements. Hiking shoes are designed with stiff bottoms enabling the shoes to grab onto rocks. Climbing shoes are made to point and give strength to the toes. If someone does not use the right shoe for their outdoor support, then knee, hip, and back pain may result. When shoes are old and worn out, they will tilt your feet, forcing you to strike the ground in an awkward way. Even the slightest angle can hurt your feet and cause back and hip pain. On average, replace the shoes you wear daily every six months at most. For other shoes, keep an eye on the soles and replace or resole them once you notice that the support is getting low.

Proper Shoe Fit

While it may seem counter-intuitive, you don't want your shoes to be tight or press too hard on your feet. In doing so, they will increase the force on your skin, increasing the chance of a blister. Here is how to fit your shoes:

- To check proper fit around your heel, place your index finger between your shoe and your foot. You should be able to slide your finger between them with little force. If your finger cannot fit, the shoes are too tight. If your finger has too much room, the shoes are too large.

- Stand up with the shoes on and make sure you have a half-inch (about the width of your finger) between your longest toe and the front of the shoe. Your toes need wiggle room so that you don't get blisters, calluses, or damaged toenails.

Lace Your Boots Properly

Every foot and every boot and shoe is different. You can nullify the benefits of your good pair of boots by not lacing or tying them correctly, and you can correct poorly fitting shoes or boots by changing the lacing. There are some general ideas about how to lace-up properly. Please watch at this video.

Click here to watch how to lace your boot correctly

Clip Your Toenails

From a medical perspective, it is critical to clip your toenails before a hike. If they're too long, your boots or shoes will push into the nails. The nail(s) will be traumatized, and blood will form under them, causing a subungual hematoma. The nails will then lift from their beds. This is painful and might quickly end the hike or trek.

Wear the Right Socks

There is no definitive data to show that wearing two socks is better than wearing just one sock while hiking or trekking. It comes down to personal preference. What is clear is having the appropriate sock to protect your feet. If you choose to have two socks, the first sock should be a thin, skin-tight, moisture-wicking synthetic sock. Its purpose is to reduce friction by fitting tightly onto your foot and reducing moisture by wicking it away from your foot to your second (outer) sock. The purpose of the second (outer) sock is to reduce friction by serving as a cushion between your foot and the boot and to reduce moisture by absorbing it from the first sock.

Hiking socks are rarely made from a single fabric, but rather from a blend that creates the right balance of comfort, warmth, durability, and fast-drying. These are the most common materials you'll find in hiking socks:

- **Wool:** Wool is the most popular hiking sock material and is recommend above all others. Most wool socks use blends of wool and synthetic materials for better durability and faster drying.
- **Polyester:** Polyester is a synthetic material that insulates, wicks moisture, and dries quickly.
- **Nylon:** This is another synthetic option that is occasionally used as the primary material. It adds durability and can help improve drying times.
- **Silk**: A natural insulator, silk is comfortable and lightweight, but not as durable as other options. It's occasionally used in sock liners for reliable moisture wicking.
- **Spandex:** Many hiking socks include a small percentage of spandex. This elastic material helps socks hold their shape and keep bunching and wrinkling to a minimum.

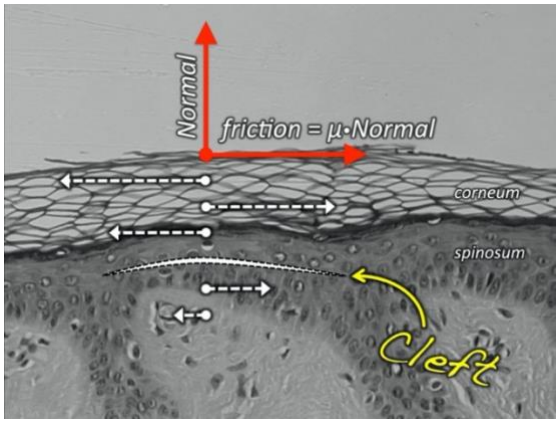
Avoid 100% cotton socks at all costs. There's a reason runners and hikers have adopted the phrase "cotton is rotten." It absorbs and collects sweat but dries very slowly. This means that when they get wet, they stay wet.

Blister Care and Hot Spots

A blister is a pocket of fluid between the upper layers of skin, but still under the epidermis. These are called the stratum corneum (dead layer calluses are composed of) and the stratum spinosum, the living layer that gives rise to the corneum. These types of blisters commonly develop on the feet when performing activities such as hiking and climbing. Blisters can be filled with serum, plasma, blood, or pus, depending on how and where they form. Blisters are formed by friction. Friction is formed by the 'normal' force. The normal force is caused by the shoe pushing on the foot. In terms of physics:

$$Fr = \mu N$$

Repeated sheering friction forces cause a mechanical separation (cleft) within stratum spinosum. Initially it is an empty space, but hydrostatic pressure fills the cleft with fluid, causing a blister to form. The maximum possible magnitude of the friction force is a function of the local normal force and the static coefficient of friction (mu). Many successful preventive strategies are aimed at reducing this coefficient of friction and reducing the normal force. Having proper material in one's socks, and having shoes that fit well are ways to lower the coefficient of static friction, as well as the normal force.



Friction blisters usually form a 'hot spot' (sore spot) first. If one of these does form, place a dual-layer pad over that area. Blist-o-ban is one such material. These pads address the two causes of friction blisters, the coefficient of friction, and forces on the skin. The dual layer will allow the bandage to glide smoothly in all directions, deflecting friction and shear forces away from the skin. The key to preventing blisters is to reduce 'hot spots' by properly breaking in boots and reducing moisture by wearing wool socks.

You can treat a blister that has already formed, by cutting a hole in moleskin of duct tape and placing the ring around the blister. This reduces the pressure placed on the blister. This should help reduce the pain too. It is not recommended to open or drain blisters that are small (<2cm or <0.75 in).

When should a blister be opened? The answer is not clear. In general, if the blister is 2 cm in diameter or larger, then it is likely to rupture spontaneously and may be amenable to initial treatment by intentionally rupturing it. However, there is no best answer to this issue. In those cases where it is large enough, or it has already ruptured, wash the area and puncture the base of the blister with a sterile needle or sterilized safety pin. Debride the external flap of skin from the blister, apply an antibiotic ointment, and cover the blister with a sterile dressing. This can be protected with moleskin or mole foam. Hydrocolloid dressings have increased in popularity, also providing protection and comfort.

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Chapter 7: Stream Crossing

While the actual number is not known, each year many people die in stream crossings while hiking and trekking. What often happens is that either the hikers do not know that a river that they need to cross is too high before they start their hike, or worse still, they are on their way back out from a hike and a rainstorm has made a small stream a raging torrent that they must cross. Hikers underestimate the risk. It's better to turn around or wait for the river to drop than risk a dangerous crossing. Know before you go, delay your trip. That's the safest option.

Safely Crossing a Stream

The Science of Stream Crossing

The physics of moving water is not favorable for crossing a stream. Water weighs 62.4 pounds/cubic foot and the pressure exerted by moving water increases with the square of its velocity. If water is moving twice as fast, it's exerting four times as much pressure. If it's moving 10 times as fast, that's 100 times the pressure. Buoyancy is a huge problem. You'll float more as the water gets deeper, which makes it that much more difficult to stand firmly on the stream bed.

How to cross a creek

Safety first. The trail is not always the best place to cross. Scout for safer crossings by walking up and down the river. You always have options if you make the time to create them. Look for slow, deeper water. It is often safer than shallower, swift water. Look for straight stretches over bends in the river. Be careful of logs. They get you out of the current and they keep your shoes dry, but they also hold their own risks and dangers. Look downstream—and consider what happens if you get swept away. If you slip and fall, you're going for a ride. Even a light current can easily push you far downstream. Don't even think about ropes unless you've been specifically trained in advanced swift water skills. They can pin you down, strangle you and kill you in a multitude of ways.

Keep your shoes on. Wearing shoes or boots makes your footing sate. It will also reduce your chance of cutting, twisting, bashing or otherwise injuring your foot. Your shoes will get wet—but they'll dry. Don't move one foot before your other foot is secure. Streambeds can be ridiculously slippery, so take it slow and pick your foot placement carefully.

In a **solo crossing**, face upstream and have three points of contact. So, use your hiking pole or grab a stick. When the current is strong, but still safe enough to cross, face upstream and shuffle across the river sideways. By crossing at a shallow diagonal angle, you can reduce the risk of being pushed backward and slipping on an unseen obstacle. Move one foot at a time. Do not cross your legs. Make small careful steps, working your way sideways.

Group crossing is ideal. If you have three people, try the triangle method. Unbuckle your packs and form a triangle facing each other. Hold on to the waist of the person next to you. Stay close together and have a leader talk the team through each step. Make sure two people are securely planted before the third person moves. Then work your way slowly across the stream as a team. If you have many people, form a wedge or rugby scrum to really break the current.

Walk your bike across a stream. It is too dangerous as the river bottom is slippery and unknown. Many people have fallen and been injured trying to ride across a stream bed.

Ditch your pack if you take a swim. Unbuckle your pack before you start your crossing so that you can quickly jettison it even if you're panicked in a creek crossing.

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Chapter 8: Back County Water Treatment

It is not difficult or time-intensive to treat water while in the back country. Portable water purification devices are relatively inexpensive, self-contained, and are easily transported into the back country. Yet gastrointestinal illness from poorly treated water is a major cause of diarrhea and dehydration in the wilderness.

The purpose of water purification is to eliminate pathogens that will cause symptoms and disease in humans. Water purification techniques can also get rid of toxic compounds and unpleasant tastes in the water. There are multiple methods that are all effective at treating water. It's recommended that you use at least two methods to ensure that the water is safe to drink.

To understand how to treat water, let's first review some Terms and Definitions:

Term	Definition
Purify	Removes taste, odor and smell
Disinfect	Removes or destroy pathogens
Sterilize	Destroys all life forms
Filtration	Mechanical process of forcing water through a membrane to remove pathogens
Effectiveness	Specialist companies will often advertise a certain reduction 99.99% effective, instead of sterilization. This takes into consideration a phenomenon known as light and dark repair (photoreactivation and base excision repair) in which a cell can repair DNA that has been damaged by UV light.

Achieving Drinkable Water

The overall goal of wilderness water treatment is to achieve drinkable water. Water sterilization is not necessary, since not all organisms are enteric human pathogens. The goal is to remove pathogens that cause disease in humans. Water purification, besides removing pathogens, also removes bad tastes and odors. While making water more tasteful it is not essential, it makes it more enjoyable. These definitions become important as you chose the method to treat water. The general public and outdoor retail stores often equate the term purification with disinfection. Advertising campaigns and promotions speak about the need to 'purify' water, when they should be saying 'disinfect.'

Overall, about 50-60% of the people who are infected by contaminated water become ill. It's important to know that illness and infection are not the same thing. A significant number of people who drink contaminated water will become infected but will not show any signs of illness. For example, most people who drink water contaminated with giardia never show symptoms at all but will still pass the cysts in their stool. For those that do exhibit symptoms, diarrhea is the most common, along with abdominal pain, bloating, and cramping. Fever and headache are also common.

The most common pathogens causing illness are:

- Bacteria
- Viruses
- Protozoa
- Parasites

The likelihood of encountering any of these microorganisms depends on the location and exposure of the water source to contamination. Watershed areas with animal grazing and human contact have higher risks than areas in which water comes from an underground source. In the wilderness, it can be very difficult to determine who or what has previously been in an area, and potentially contaminating water sources.

Finding the Best Water

To process of making water safe to drink starts with finding the best available water. Streams are able to purify themselves thanks to settling, UV rays, and predatory bacteria. Settling is when the dirt and harmful particles settle out to the bottom of the stream and aren't carried in the current. Because streams are so small, the UV rays from the sunlight are able to damage or destroy the pathogens that can exist in the water. If no stream is around, it is a reasonable choice to skim the top layer of a clear lake because the UV rays from the sun will still have cleaned the top layer. Whether you do or do not have methods to treat water, these are your best water sources.

A slow flowing river and a pond are the worst places to get water because bacteria and parasites tend to thrive in these environments. If your only choice is to drink from a water source that isn't flowing rapidly, be aware that blue-green algae can produce toxins that can make you sick. Water treatment will not get rid of the toxins. Even after an algae bloom has died off, the toxins can remain in the water if it's stagnant. The only way to avoid this problem is to plan your hike so don't have to drink from such sources.

The single most important aspect of finding good drinking water is to get close to the source. For example, you can look for a watercourse that is draining from a large snowbank high on a steep slope. The second most important principle is to make sure the water is cold. Test the water with your hand to see if it is quite cold. Extremely cold water means it has not traveled far from its icy source. Also, look for fast-moving water. These streamlets very often drain a melting snowbank during the warmer months.

Pre -Treatment

Once the best source of water has been found, then pretreatment might be necessary. This is done if the water has contaminants such as sediment, leaves, small twigs or particles. It is important to understand that these pretreatment procedures do not disinfect water. However, they will enhance the disinfection process and drinking experience. Organic and inorganic particles can interfere with the disinfection process particulary with UV irradiation as sediment absorbs UV light. Bacteria, viruses and other pathogens are found on particles in water, so removing them is essential.

Screening

The screening process is the first step in the pretreatment of water and is intended to remove the largest of the contaminants. It involves using a primary filter as a screen to hold back dirt, plant, and animal matter. Many filtration systems already have a "pre-filter" attached. If filling a container by dipping or pouring, one can screen out unwanted debris by pouring the water through a cloth, such as a bandana, handkerchief, or even a T-shirt.

Standing

This is the second step, and allows particles that were too small to pass through the screening material to fall to the bottom of the container. Within as little as one hour, even muddy or turbid water will show significant improvement as the silt settles.

Flocculating

This is a method of removing particulate matter that are so small they would normally stay suspended in water indefinitely. You add specific chemicals to the water that cause agglomeration of the particulates until a complex forms-up, that is large enough to precipitate. This process takes a number of minutes. One common chemical used is "alum," often used in canning and pickling. It is easily found in grocery stores and is also a component of baking powder. As well, the fine, white ashes from burned wood are rich in mineral salts that can be used.

Water Treatment - Boiling

Boiling water will kill all human pathogens. The thermal effectiveness for killing pathogens depends on a combination of temperature and exposure time. Because of this, lower temperatures can be effective if the contact time is longer. However, without a thermometer, it is too difficult and risky to gauge temperature short of boiling.

The Centers for Disease Control in the United States (CDC) recommends boiling water for at least (3) three minutes if your location is above 6,562 feet (2000m). One important characteristic of boiling points is that they decrease in temperature with increased elevation. For instance, water boils at only 86°C (187°F) at an elevation of 14,000 feet (4,300m). The boiling point of water at sea level is 100°C (212°F). At this temperature, disinfection has generally occurred by the time the water boils. This is because most organisms are effectively killed at temperatures below this boiling point (see table). However, since it is difficult to determine the exact temperature of the water, boiling it for (3) three minutes is the safest way to ensure that the water has been treated.

The disadvantage to this is that the water is now hot and doesn't taste very good, unless you are making soup. If you are in a hot environment, it will never cool down. Another disadvantage is that the gear needed to boil water is usually heavy to carry.

Effective Times for Disinfection Using Heat

Pathogen	Thermal Death
Giardia lamblia, *Entamoeba histolytica* cysts	After 2 to 3 minutes at 60° C (140° F)
Cryptosporidium oocysts	After 2 minutes at 65° C (149° F)
Enteric viruses	Within seconds at 80° to 100° C (176° F to 212° F)
Bacteria	Within seconds at 100° C (212° F)
Hepatitis A virus	After 1 minute at 92° C (198° F)

Water Treatment - Filtering

Filters screen out bacteria, protozoa, and helminths, including their cysts and eggs. However, they are not reliable for eliminating viruses. Viruses tend to adhere to other particles, or clump together, which allows some of them to be removed by filtration. Nevertheless, because they are so small (less than 0.1 micron), that viruses cannot be eradicated by filters alone. Some filters are impregnated with an iodine element in an attempt to destroy the viruses as they pass through the material. However, these additions are of questionable efficacy, lifespan, and are expensive. Most filters only filter things that are larger than 0.3 microns.

Because filters work by trapping small particles in their pore matrix, they clog and become less effective over time. Operating a pump as it becomes clogged can force pathogens through it and contaminate the water. Some new water filters will actually 'backwash' the filtering mechanism to help avoid this problem. Interpreting advertised filter specifications can also be difficult. The best way to evaluate a given filter is to ascertain its functional removal rate of various organisms. For example, a filter labeled "effective against pathogens" does not truly describe its efficacy.

For practical usage, filters could be utilized as the only disinfection method in areas where human and animal excrement is low, and in watershed areas that are protected. In these situations, recent rainwater that has landed in the middle of a trail has likely not been contaminated with human or animal waste. When uncertain, one should use an additional method of disinfection (i.e. halogenation) as a final step.

Chemical/Halogenation Treatment

Iodine and chlorine can be very effective as disinfectants against viruses and bacteria. Their effectiveness against protozoa and helminths, as well as their eggs and cysts, varies greatly. For example, while Giardia lamblia is effectively killed, Cryptosporidium cysts are extremely resistant to halogen disinfection. The amount of halogen required is impractical for drinking.

However, the major problem with chemical disinfection is improper treatment by the user. Disinfection depends on both halogen concentration and contact time. Factors that affect halogen concentration include water temperature, pH, and the presence of contaminants. Chlorine is more sensitive to these factors and is thus less suitable for cold, contaminated water. In these conditions, halogens require increased contact time and/or concentration. Turbid water should be allowed to settle before halogenation because particulate matter can deactivate the available

halogen, rendering disinfection incomplete. Household cleaners, such as bleach, vary widely in concentration and are not a recommended chlorine source for disinfection of drinking water as they have some efficacy against bacteria, but not viruses.

Another challenge with chemical treatment, although not as serious a problem with halogens, is their unpleasant taste. This can be remedied in several ways but must be done after disinfection. A "pinch" of ascorbic acid (vitamin C) has been shown to neutralize taste, closely matching that of distilled water. Flavored drink mixes, especially containing ascorbic acid, can also help mask the unpalatable iodine or bleach flavor.

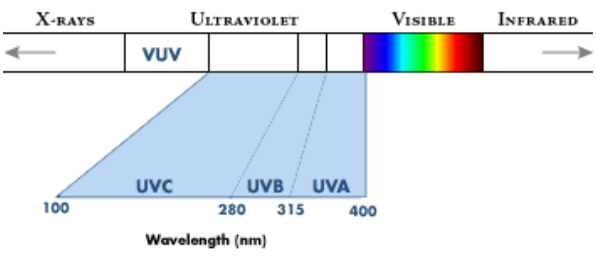
Iodine is an effective, simple, and cost-effective means of water disinfection for people who are in the wilderness and need to treat their water. However, there is considerable concern about its potential effect on the thyroid gland. There is controversy about the maximum safe iodine dose and duration of use when iodine is ingested in excess of the recommended daily dietary amount. Most recommendations are that people should not exceed 2 mg/day for more than 3 weeks. However, these are not firm guidelines as there appears to be an individual response. Thus, the use of iodine for water disinfection requires a risk-benefit decision based on iodine's benefit as a disinfectant and the changes it induces in thyroid physiology. By using appropriate disinfection techniques and following guidelines from the manufacturer, most people can use iodine safely.

It is possible to use a much lower concentration of iodine if the contact time is longer or the water temperature is warmer. Colder water requires a higher concentration of iodine and longer contact time. The major health concern with excess iodine ingestion is thyroid toxicity. There has never been a link between the intake of iodine and cancer and there are no known allergies to this element. Iodine does not slow mental function.

Summary of Treatment Method Efficacy

Infectious Agent	Heat	Filtration	Chemical
Bacteria	+	+	++
Viruses	+	-	+
Protozoa and cysts	++	++	+
Helminths and oocytes	++	++	-

Ultraviolet Radiation (UVR) Treatment



UVR has recently gained popularity as a portable means of water disinfection. UV light is electromagnetic radiation. Ultraviolet (UV) rays penetrate harmful pathogens in water and destroy illness-causing microorganisms by attacking their genetic core (DNA). UV radiation has three wavelength zones: UV-A, UV-B, and UV-C.

It's this last region, the shortwave **UV-C**, that has the germicidal properties that cause disinfection. The effectiveness of this process is related to exposure time and lamp intensity, as well as general water quality parameters. Ultraviolet light treatment does not remove organisms from the water, it

merely inactivates them. UV light acts on thymine, one of the four base nucleotides in DNA, preventing microbes from reproducing. Without reproduction, the microbes become far less dangerous. UV radiation does not improve the taste, odor, or clarity of water.

Disadvantages of UV Light Treatment

Dosage factors

Recent studies show that viruses present a limiting factor for UV treatment. Viruses require a dose of UV light that is (10) ten to (30) thirty times greater than for cysts (such as Giardia or Cryptosporidium), and bacteria. Another concern with UV portable water purification is that some pathogens are hundreds of times less sensitive to UV light than others. Protozoan cysts were once believed to be among the least sensitive. However, studies have proven otherwise, demonstrating that common cysts such as Cryptosporidium and Giardia are deactivated by low dose UV light.

Levels of Turbidity

Water must have a low level of turbidity for UV treatment to work effectively. Dissolved organic matter, such as natural organic matter; certain inorganic solutes, such as iron, sulfites, and nitrites; and suspended matter and particles will absorb UV radiation or shield microbes from UV radiation. This results in lower delivered UV doses and reduced microbial disinfection. Thus, a pre-filter step to rid water of particles might be necessary. UV water works as well in cold water as it does in warmer water. The number of bacteria has no effect on UV irradiation.

Reactivation of Pathogens

Reactivation of pathogens is a significant risk in water that has been treated with UV irradiation. Water treated with UV radiation still contains the microbes present in the water, with their means for reproduction having been turned "off". However, in the event that such UV-treated water containing neutered microbes is exposed to visible light for any significant period of time, a process known as photo reactivation takes place. In order to avoid ingesting reactivated and dangerous microbes, UV treated water must not be exposed to visible light for any significant period of time prior to consumption.

No Residual treatment

The other long-term disadvantage is that ultraviolet purification offers no residual treatment. Unlike chlorine which maintains a presence in the water after the treatment and continues to disinfect the water, ultraviolet radiation does not stay in the water. Any microorganisms that the radiation missed would remain in the water whereas chlorination would destroy them. For this reason, a chlorine compound should be added to water already purified by ultraviolet radiation.

Other drawbacks

Ultraviolet radiation has several other potential drawbacks to consider. Extra batteries may be needed for longer trips, and the lights themselves tend to be fragile if dropped.

Chlorine Dioxide Treatment

This compound has shown promising results. Liquid and tablet options are becoming increasingly commercially available. It has a wider range of effective pH and often does not require more than simple mixing.

Giardia lamblia and Cryptosporidium cause diarrhea in backcountry travelers. Their cysts are generally readily filtered from water, but chemical treatment of both cysts has proven problematic. Cryptosporidium is highly resistant to chlorine disinfection. Giardia cysts are much less responsive to chorine but somewhat more sensitive to iodine with high enough concentrations and contact time.

Recent studies have shown that both Cryptosporidium and Giardia inactivation will occur with chlorine dioxide treatment. Chlorine dioxide is very different from elementary chlorine. Despite the name, chlorine is not the chemical that ends up purifying the water. Chlorine dioxide releases a very reactive form of oxygen (similar to ozone) that neutralizes pathogens.

One of the most important qualities of chlorine dioxide is its high-water solubility, especially in cold water. Also, chlorine dioxide imparts a much less offensive taste than other halogens used to purify water. Chlorine dioxide has been used safely in industrial and municipal applications for over 70 years.

MSR MIOX Treatment

Unlike water filters, the MSR MIOX requires no pumping, virtually no cleaning, and does not have the potential to clog in the field. If operated correctly the MIOX adds little if any of the bitter or salty flavor produced by many tablets and drops. The device also kills more of the potentially dangerous microorganisms than most other water treatment options. Unlike ultraviolet treatment methods, MIOX treatment is unaffected by the cloudiness of the water, but it does not remove particles. The multi-step process that produces the treatment solution comes with a steep learning curve. Salt and water are added to their respective chambers, sealed, and shaken to combine through a screen that separates them. If not enough of either ingredient is added, the combination can fail.

MSR MIOX uses electrolysis to create a disinfectant that destroys biological contaminants in water. It is more effective against most microorganisms than chlorine or iodine. Though the MIOX treatment means certain death to the bad stuff living in water, the waiting time for this process can be a drawback. Most viruses and bacteria are killed within 15 minutes, with Giardia in 30 minutes. However, to ensure that Cryptosporidium is killed, the wait time is about 4 hours. If Crypto contamination is a possibility, proper water planning and rationing might be necessary with these wait times.

Purifying Water

Tannins and humics are natural organic matter that leach into wilderness water as plants decay, staining it a tea color. They're not harmful in small quantities, but they do impart odors and a bitter taste to the water.

Sediment in the water gives it a dirty appearance and is unpleasant to ingest. It usually isn't harmful in small amounts. Sediment is not seen in high amounts in clear mountain lakes.

Ordinary salts are the result of eroding natural deposits or seawater contamination, salts simply make water taste bad; though very high concentrations can dehydrate you. When exploring coastal

and desert regions, avoid drinking sea and brackish waters. Salt is not likely seen in a mountain lake.

Using an activated carbon filter can remove bad taste and purify the water. Activated carbon has long been used in treatment devices because of its absorptive properties. Activated carbon is great for catching many contaminants that are so small they pass through a micro-filter. Simply put, it is tiny bugs or germs that are the primary focus of treatment because of their immediate and serious risk to health.

Beware of Ice

Several studies have recently suggested that mold and bacteria in ice machines are a much larger cause of illness than previously thought. The cold temperatures of a house freezer may make it harder for mold and bacteria to grow, but problems start when freezers are regularly turned off for extended periods of time. Owners don't always clean their freezers. In addition, when people take ice without washing their hands and then drop the scoop back into the ice, the cubes can become contaminated from the contaminants left by unclean skin. People can have a reaction after consuming a slug of mold or bacteria that was on the ice.

Water from the hotel drinking fountain could potentially be the source, but much less likely than that of the ice. Fruit typically does not carry bacteria that cause diarrhea.

If a person picks the ice out of a tray with unwashed hands, then the ice will become contaminated. In 2007, a study conducted in London found that nearly 20 percent of 49 restaurants and hotel bars had ice contaminated by high levels of fecal coliform bacteria. People must remember to wash their hands before meals, but they don't remember to wash their hands each time they grab ice. In 2012, a 15-year-old boy in Florida died from consuming contaminated ice, a death that could have been prevented by handwashing. Most people don't realize that death can be caused by contaminated hands.

The Table below categorizes some of the possible Waterborne Pathogens:

Bacteria	Viral Agents	Protozoa	Helminths
Escherichia coli *Shigella* *Campylobacter* species *Salmonellae* *Yersinia enterocolitica* *Aeromonas* species *Vibrio cholerae*	Hepatitis A Hepatitis E Norwalk agent Poliovirus Rotavirus	*Giardia lamblia* *Entamoeba histolytica* *Cryptosporidia* *Cyclospora* species *Blastocystis hominis* *Acanthamoeba* *Balantidium coli* *Isospora belli* *Naegleria fowleri*	*Ascaris lumbricoides* *Taenia* species *Trichuris trichiura* *Fasciola hepatica* *Strongyloides* species *Echinococcus* *Diphyllobothrium* species

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Chapter 9: Eating Right before the Hike

Fueling your body properly is a key part of any hike. If you have a strong stomach and you're only going on a short hike, you can eat almost anything. Head out for multiple days, however, and you'll want to plan more into account proper backpacking nutrition can lead to bonking (where your body crashes due to a lack of energy), hunger, dehydration, and a plain bad time. But when you give your body what it needs, you'll feel strong and comfortable on the trail. Follow these rules of backpacking nutrition and you'll be at your hiking peak

Fuel with carbs

Eat a lot when you are in the backcountry. It is no time to diet. What do you eat? Carbohydrates are the body's preferred primary energy source while hiking and backpacking since they're easier for your body to process than fats or protein. We use glucose exclusively for quick muscle contraction movements such as jumping, running, climbing, and forceful paddling. Backpacking nutrition wisdom holds that you should eat 30 to 60 grams (120 to 240 calories) of carbohydrates per hour. This will keep you going. It will improve strength and endurance and delay fatigue and hitting the 'wall.' If you don't consume enough carbohydrates, the body will burn muscle protein and stored body fat. You will feel weak and might not make your goal. A few examples of good carb choices while hiking are energy gels, shot blocks, sports drinks, dried fruit, and protein bars and candy bars. Great sources of carbohydrates to include in your eating patterns prior to hiking include whole grains such as brown or wild rice, quinoa, oats, and whole grain pastas/breads; starchy vegetables such as potatoes, peas, and winter squash; beans, legumes, and lentils; and fruits of all kinds. That is because we can store a lot of energy in our muscles and liver and blood before a hike.

You should eat 30 to 60 grams (120 to 240 calories) of carbohydrates per hour when hiking

It may be difficult to consume as many carbohydrates as recommended, and it's important that your diet is composed of a variety of nutrients, not just carbohydrates. Adjust your diet appropriately and focus on timing of meals. Make sure to eat before, during, and immediately after physical activity and always keep some easily digested carbohydrates in your 24-hour kit/backpack such energy gels, honey, jelly, and hard candies.

Consume electrolytes

You should drink electrolytes not just water, particularly when you are in the heat. As the temperatures rise, not consuming enough electrolytes can be as devastating to your performance. For performance levels to remain high, you need to replenish sodium, chloride, potassium, magnesium, manganese, and calcium on a consistent basis. High water intake without electrolyte replacement over many hours will not be enough. And it can lead to hyponatremia. This can be a life-threatening condition where your body doesn't have enough salts to function. Electrolytes help retain fluid by drawing water into cells. An

You should drink electrolytes, not just water.

electrolyte supplement or sports drink with electrolytes is beneficial if you are drinking a large volume of fluid, and/or sweating heavily. This is especially important for rehydration following exercise. To avoid electrolyte imbalance, you need to consistently replenish by consuming salty snacks such as pretzels, salted nuts, or salted chips or drink electrolyte replacement sport drinks. If you are going to treat water as your primary water source, you can add electrolyte supplements.

Eat for recovery as soon as you are done

There is a 30 to 45-minute post-exercise window when your body is especially receptive to replenishing and repairing muscle tissue. A 4:1 ratio of carbohydrates to protein is ideal. The carbohydrates replace lost muscle sugar (glycogen) and protein provides amino acids to repair the muscle tissue. Powdered sports recovery drinks are a good option because they are in a powdered form and have everything tired muscles need. Really any whole foods are great.

Yes, Drink before you feel thirsty

We don't think of it this way, but hydration is a part of nutrition. Thirst is an early symptom of dehydration. By the time the thirst response is activated, you're already 2 to 3 percent dehydrated. This will diminish endurance by 10 percent. Start your hike hydrated by consuming 14 to 22 ounces of water about 2 hours before exercise. During the hike, drink to thirst: A good goal is to drink 6 to 12 ounces of water or sports drink every 15 to 20 minutes. Recover by drinking 16 to 20 ounces of water or sports drink every hour for a few hours after the hike to fully rehydrate.

Here is a sample schedule of how you should eat before the hike or outdoor event. The foods given are examples and not the only foods that would result in peak backpacking performance.

Weeks Before

Include carbohydrates in your eating patterns such as:

- Brown or wild rice
- Quinoa
- Oats
- Whole grain pastas
- Whole grain breads
- Starchy vegetables
- Beans
- Legumes
- Lentils
- Fruits

2 Hours before

Drink 14-22 ounces of water

During

Drink water and electrolytes to thirst (6-12 ounces per 15-20 minutes)
Eat carbohydrates (30-60 grams per hour) such as:

- Energy gels
- Shot blocks
- Dried fruit
- Protein bars

- Candy bars

After
Drink 16-20 ounces of water or sports drink every hour for several hours
Eat whole foods or a powdered sports recovery drink within 30-45 minutes

Chapter 10: Children in Wilderness Settings

Introduction

Youths ages 6-17 years participate more frequently in outdoor recreation than older people. The most popular outdoor activities undertaken by such children and teenagers include biking, running, fishing, camping, and hiking. Adults with children in the household are more likely than those without children to undertake outdoor recreation. Adults with children 6-12 have some of the highest participation rates in outdoor activities. In the busiest outdoor locations, children and teenagers may be frequently encountered and thus may require special attention from the wilderness medicine provider.

The Benefits of Wilderness Experiences for Children

Outdoor recreation and wilderness experiences provide a catalyst for the emotional and social maturation of children. Within the family unit, various studies have backed the assertion that family participation in outdoor recreation can deepen adults' and children's perspectives of family cohesion, communication, and cooperation, and may even help smooth dysfunctional relationships. In addition, families of children with disabilities have also demonstrated increases in family satisfaction and cohesion when undertaking outdoor recreation, improving the families' confidence when facing barriers to the inclusion of the child with disabilities.

Hazards and Risks Unique to Children

Despite the potential benefits of outdoor recreation and wilderness experiences, children may be exposed to unique risks and dangers due to their size and physiology. While these are numerous in scope, essential points to understand for the wilderness medicine practitioner follow from children's differences in body mass and surface area compared to adults; their essentially less efficient ability to thermoregulate body temperature compared to adults.

Case Study

Philip was 10 years old when he and 10 other family members began backpacking down the South Kaibab Trail in Grand Canyon National Park on July 23rd, 1996. They planned to travel from the rim to the river in one day, with an overnight stay in Phantom Ranch at the base of the canyon. Unfortunately, this hike was undertaken on the hottest day of the year at 10 AM in the late morning, long after cool nighttime temperatures were dissipated by the Arizona sun. While still close to the rim, the family was warned by a National Park Service (NPS) ranger to turn back due to their lack of water and preparation. It should be noted the South Kaibab trail is largely unsheltered from the sun, and temperatures at the base of the canyon were 116 degrees in the shade on that day. Despite the warnings and clearly uncomfortable temperatures, the family chose to continue.

As they meandered down the trail, the 11 members of the family began to spread out over two miles. The fastest hikers, 10-year-old Philip and his great uncle, sped ahead of the others to the river in the midday heat. Along the way, Philip's great-uncle offered to carry the boy's backpack and water. Philip had found the backpack uncomfortable and was only sipping the water infrequently, because it was warm and unpleasant to drink. He agreed and gave his great-uncle the backpack.

As the hike went on, Philip gradually became visibly fatigued and exhausted. His great uncle eventually passed him only several hundred yards from Bright Angel creek in the base of the canyon, close to their final destination at Phantom Ranch.

Philip collapsed before reaching the cool waters of the creek. When he was found, his body temperature was elevated to 106 degrees, he had ceased breathing, and his pulse was faint. NPS rangers were notified and initiated cardiopulmonary resuscitation and a helicopter evacuation. Meanwhile, on the trail above, Phillip's grandmother and great aunt also collapsed due to heat stroke. NPS rangers likewise began active cooling measures and subsequently called in a helicopter evacuation for the two older women.

Despite the efforts of the NPS rangers and Grand Canyon medical staff, Phillip did not survive. His grandmother and great aunt were successfully resuscitated and recovered.

Understanding Pediatric Body Mass and Surface Area

Children's body mass changes rapidly over the course of 18 years, ranging from 3 kg as a term infant to 70 kg or more as a young adult. During these dramatic changes, the body surface area to mass ratio also changes dramatically. A 3.4 kg infant may have a body surface area of 0.212 m^2, which achieves a surface-area-to-mass ratio of 0.062 m^2/kg. A 70 kg young male may have a body surface area of 1.82 m^2, which achieves a surface-area-to-

mass ratio of 0.026 m^2/kg. The difference is almost a 2.5-fold disparity in relative body surface area.

The disparity in the physiology of children illustrates that their core body mass is fundamentally more exposed to environmental insults than adults. For example, in cold settings, a child's body heat may be lost more rapidly by convective, conductive, and radiative transfer into the environment due to their greater surface-area-to-mass ratio. In hotter settings, dehydration may occur more rapidly through evaporation of sweat over a relatively larger surface area covering a comparatively smaller mass. In instances of sunburns and thermal burns, damage to the outer layer of skin per unit of surface area may translate to a greater relative systemic inflammatory response than in adults.

Likewise, exposure to intoxicants and envenomation may be dramatically different for children than for adults. As illustrated above, a newborn baby's mass is nearly 1/20th of an adults. Thus, as an example, infants and small children may suffer life-threatening systemic effects from envenomation due to the distribution of toxin in a much smaller mass, while an adult might instead experience a mere painful misadventure.

Pediatric Thermoregulation, Hyperthermia, and Hypothermia

Children's body mass and relative surface area may predispose them to temperature-related environmental insults beyond those which adults may face. Additional unique aspects of pediatric physiology may also be responsible for children's greater vulnerability to hyperthermia and hypothermia in different settings.

The human body typically employs sweating and skin vasodilation to regulate core body temperature in hot environments. Vasodilation of surface capillary beds helps effect heat transfer from the core mass to the outside environment by directing blood flow to the skin for heat dissipation. Heat dissipation then takes place at the level of the skin by dry radiation, convection, and conduction, as well as through sweat evaporation. , children demonstrate lower overall rates of sweating when compared to adults, especially among toddlers and infants. When combined with a lower overall cardiac output (and thus a less efficient heat transfer mechanism from the core to the surface), children's lower rates of sweating thereby lead to higher core temperatures during exercise in the heat. Because of these factors, children are typically believed to be at greater risk for heat injury, especially those 0-4 years old.

The physiologic properties of human heat loss that serve usefully in hot environments may also become a liability in cold environments, particularly for children. Loss of warmth through convection and evaporation may be worsened by wet skin or exposure to wind. Additional heat loss may occur through respiration, particularly during periods of exertion and exercise. In healthy adults, the human body compensates for such losses through

vasoconstriction of skin capillary beds, along with shivering and increased metabolism. Adults may also harbor substantial subcutaneous fat stores for some additional insulation. Finally, adults are also more likely to employ learned and behavioral strategies to seek shelter from the wind and cold. In contrast, children are at greater risk of hypothermia and cold injuries, principally due to their lower mass to surface area ratio, a relatively compromised shivering mechanism (absent in young infants), lower glycogen stores to support increased metabolism for prolonged periods and a lower percentage of body fat by weight to serve as protective insulation. Children are also less likely to employ appropriate learned and behavioral strategies to protect themselves from the cold. Finally, and for the reasons above, children may suffer hypothermia in less extreme environments than adults, potentially leading to unrecognized hypothermia and cold injury--and thus delayed attention--by their adult caregivers and medical professionals.

Pediatric Energy Metabolism and Stamina

Children are at greater risk of fatigue and hunger due to fundamental differences in energy metabolism and reserves when compared to adults. Not only does this impact their performance and capacity for endurance in outdoor recreation, but it also predisposes them to starvation and malnutrition in survival situations. These differences are in large part due to children's physiologic greater energy requirements per unit mass and their lack of energy reserves.

Children undergo rapid rates of growth over the course of only 18 years, starting from a 3 kg infant and ending as a 70 kg adult. To provide the caloric substrate for such growth, children must consume and metabolize a greater number of calories per kilogram of unit mass than their adult counterparts. For example, a 1-year-old male infant must consume nearly 2.5 times the calories per kilogram that an 18-year-old male must sustain growth and healthy metabolism.

In a similar vein, children are typically unable to accrue and sustain the same proportions of energy reserves that a healthy adult might. These energy reserves come most readily in the form of liver and muscle glycogen, which breaks down to provide steady serum glucose levels during periods of fasting between meals. Greater proportional reserves of glycogen allow the body to sustain activity and fast for longer periods of time. For example, the average adult can maintain a fasting serum glucose level above 70 mg/dL for 48 to 72 hours. In contrast, a 5-year-old may only be able sustain such a fasting glucose for 36 hours, and a 1-year-old infant for 24 hours. Young infants under 1 year of age will not tolerate a fast greater than 15-18 hours before serum glucose levels fall under 70 mg/dL. Physical activity will deplete such reserves more rapidly, such as when recreating outdoors, or in more extreme survival situations.

Thus, any adult who accompanies children in the outdoors should be aware of the metabolic limitations of children's physiology. Children who undertake energy expenditure in outdoor situations must be richly compensated with appropriate calories in the form of frequent snacks and meals.

Pediatric Musculoskeletal Maturity and Injuries

The musculoskeletal system of children is unique in multiple aspects when compared to adults. Most obviously, this is due to the presence of epiphyseal plates within long bones, which are cartilaginous osteogenic growth centers. In addition, children's bones exhibit larger amounts of periosseous cartilage when compared to adults and are less dense and more porous. They are also sheathed in a thicker, stronger periosteum.

The practical consequences of children's unique musculoskeletal system led to several principles that should be recalled when caring for pediatric victims of trauma, major or minor. The first, and most important, principle is that joint injuries, dislocations, and ligament injuries are less likely to be encountered in children. In practical terms, this means that fractures to the bones end plate are more likely than a simple "sprain." Thus, any caregiving adult or medical provider who supposes a young child has suffered a "sprain" from a minor trauma should beware of misdiagnosis and consider the likelier possibility of a growth plate fracture.

The Neurodevelopmental Maturity of Children and Adolescents

Children and adolescents demonstrate differing capacities for negotiating the obstacles, hazards, and risks of wilderness environments. While such capacities are largely derived from the neurodevelopmental stage and temperament of the individual child, learned behaviors from family and mentor relationships may improve the child's ability to recognize and navigate risky situations.

In the span of several years, children exhibit a dramatic evolution from utter dependence to increasing attempts to assert their independence and curiosity. Thus, adult caregivers must be continually wary of the toddler and young child's propensity to wander. School age children typically demonstrate improved listening skills, adherence to rule-setting, and appropriate caution in dangerous situations. Adolescents, however, may seek to explore risks more boldly, particularly when accompanied by members of their peer group. All such tendencies are modified by the individual child's temperament--for example, siblings within the same family may demonstrate markedly different approaches to asserting independence, such as quietly venturing forth and disobeying a parent's calls to return, versus staying close to the parent and exhibiting a tantrum.

The consequences of this spectrum of behaviors may lead to numerous outcomes in outdoor recreation and wilderness experiences. These can range from a child's newfound confidence in exploring her abilities, to minor misadventures, to tragic accidents or lifelong consequences. The parent or caregiver's ability to teach, monitor, encourage, and caution the child's exploration of the outdoors, appropriately tempered by the caregiver's assessment of risk, will help prevent severe consequences and provide a higher likelihood of success and positive outcomes. Moreover, parents and caregivers may teach such risk-assessment skills, along with knowledge of the natural world, safety systems, reasonable personal limits, and survival strategies to improve children's capacity for navigating wilderness experiences. In fact, such knowledge may also serve to empower the child's confidence in facing and appropriately avoiding hazards, with potential lifelong benefits.

Case Study

Stratton Wright was 9 years old when he embarked upon a family hike during a pleasant July outing in the Uinta mountains of Utah in the USA. However, sometime around 8 PM, Stratton became separated from his family and found himself lost within the seemingly endless forest. He was unable to locate any familiar landmarks or make his way back to the trail.

However, rather than panicking and wandering farther into the forest or expending more energy, Stratton made himself comfortable and stayed put through the night. In the morning, he made his way into an open field, where he knew searchers would have an easier time spotting him. He was soon found and rescued that day without further incident.

Understanding and Addressing Lost Child Behavior

Case Study

In February 1981, 9-year-old Jimmy Beveridge and his two brothers embarked on a short walk on a well-used nature trail beyond their family campsite. Their family was on a car-camping trip on Palomar Mountain, 60 miles from San Diego, California. As the boys raced back to the family campsite, Jimmy was outpaced by his two older brothers. After arriving back at camp with their parents, they realized Jimmy was no longer behind them. The family searched for an hour before calling the Sheriff's department.

Temperatures dropped overnight as clouds and fog rolled in. Visibility over the next several days was reduced with frequent rain. The search was expanded and further assistance was recruited from the San Diego Mountain Rescue Team, local volunteers,

professional man-trackers, and US Marines from a nearby base, numbering over 400 individuals. Helicopter support was limited due to poor visibility.

Jimmy's body was found four days later. He had died of hypothermia, nearly two miles from his campsite.

Ab Taylor was one of the professional trackers involved in the search for Jimmy. The incident marked the first time in his 31 years as a tracker he had failed to find a missing child alive. Heartbroken but determined to prevent another tragedy like Jimmy's, he founded the "Hug-a-Tree-and-Survive" program (see below), which teaches children lost in wilderness and survival situations to stay put, make themselves known to searchers, and stay warm while awaiting rescue.

The program is now presented in countless venues each year throughout the United States and Canada through the National Association for Search and Rescue, as well as by local Search and Rescue Teams and law enforcement agencies.

Children who become lost in wilderness settings display a wide range of behaviors. Many of these behaviors can be stereotyped based on prior search and rescue and law enforcement databases "finds" and case studies.

Lost toddlers (ages 1-3) and small children (ages 4-6) typically trigger very early and aggressive search and rescue responses. They rarely travel far from their last known location. The youngest in this age group usually display aimless wandering when lost or separated from their parents, although they may be attracted to bodies of water and animals. Certain aspects of their neurodevelopmental age may represent significant challenges to search and rescue teams. These children are less likely to respond to searchers due to their fear of strangers and may remain silent even as their own parents call their name, due to a fear of "getting in trouble" for being lost. In addition, many may attempt to squeeze into small spaces or penetrate the brush in order to sleep or hide. However, because of their propensity to find hiding places, their survival is somewhat enhanced by taking shelter from the elements.

School age children (ages 7-12) may travel much farther when lost or separated from their parents or recreation group. They may become lost due to misdirected attempts at taking a shortcut, or they may sometimes strike out on their own as means of avoiding punishment or sulking. However, their survival is improved by their ability to make special note of decision points in their progress, and thereafter utilizing strategies like following trails and roads, or staying put in a familiar location. They are also more likely to take shelter in built structures or vehicles.

Adolescents (ages 13-15) who become unintentionally lost are capable of the highest rates of survival. They are often accompanied by friends or peer groups, which adds to their survival success. They may employ various learned survival strategies or navigation techniques. However, adolescents are also likelier to be runaways who have deliberately struck out from home or are evading a caregiver. They may also be overdue in wilderness areas because of a deliberate suicide attempt.

Hug-a-Tree and Survive

Professional man tracker Ab Taylor helped design and promoted the earliest versions of the Hug-A-Tree and Survive program in the 1980s, in response to the tragedy of Jimmy Beveridge. The program has been refined since its inception and presented at countless schools and community gatherings in the ensuing years. The essential points of Hug-A-Tree and Survive are focused on encouraging children to stay put, prevent hypothermia, and make themselves known to searchers in survival situations.

First, the program asks children to recognize that when they are lost, they must stay put, as wandering around or striking out in various directions is likely to lead to delays in recovery. The program asks children to pick a tree that seems comforting and that can serve as a landmark, and then to "hug" the tree or take shelter beneath it. If the child sees a clearing, she should also try to pick a tree in the open or at its edge, as airborne searchers will have an easier time spotting the child. Children may also use the environment or their own supplies to create signs indicating where they are, e.g. using downed branches to create an arrow in a clearing pointing to their tree, or hanging a piece of clothing as a flag.

Second, the program asks children to avoid hypothermia by always bringing a garbage bag or emergency blanket in their backpack when hiking. While lightweight, a garbage bag can provide an effective layer of insulation and a wind barrier that will allow overnight survival in temperate climates. Emergency Mylar blankets are even more effective, as they are designed to reflect body heat. The child may also be taught to insulate themselves from conductive heat loss from the ground by sitting on their backpack or pine boughs and branches.

Third, the program teaches children to utilize an emergency whistle to make themselves known to searchers. Calling for help is likely to lead to exhaustion, but whistle blasts are easy for a child to perform for long periods of time. If a child sees or hears searchers, they should make themselves clearly known with whistle blasts and standing up to gain their attention. The rule of threes—three whistle blasts in a row, or three headlamp flashes, etc. indicates distress—should be emphasized. Young children should be taught that they are not in trouble, they will not be "arrested," and that searchers and police officers are here to help them.

Case Study

9-year-old Michael was playing with his brothers in a wooded area at Mount Laguna in San Diego County, CA in 1990. However, he became separated from his brothers and could not recall the way back to his family. Realizing he was lost, Michael drew upon what he had previously learned during a Hug-a-Tree and Survive presentation. He chose to stay in one place and burrowed into a pile of pine needles and leaves to stay warm. Temperatures that night reached 36 degrees.

Despite the significant risk of hypothermia, Michael was found alive and well the next morning, 16 hours after his disappearance.

Preparations for Adults Accompanying Children in Wilderness Settings

The following suggestions may be helpful to parents, caretakers, counselors, guides, scoutmasters, and teachers.

1. Bring extra warm layers: This should apply even when children (or their parents) are asked to pack their own bags, as temperatures may sometimes be colder than anticipated.

2. Bring extra food and snacks: Children will quickly become fatigued and perhaps more difficult to motivate when tired and hungry. The provision of calories is always helpful on hiking and outdoor adventures, given their lower glycogen stores when compared to adults.

3. Bring extra hygiene items: Those with toddlers and infants will recognize that extra diapers, wipes, changes of clothing, and other hygiene items may be crucial if the child experiences a “blow-out” or other accident.

4. Ensure adult supervision is adequate: the safest ratio of adults to children is variable and depends upon the age of the children and the circumstances of the adventure. Some employ a ratio of 2 adults for every toddler or infant, reasoning that if an adult is injured or must leave the camp to seek help, there must be one unencumbered adult left to care for the child. Lower ratios of adults to children are appropriate for older age groups, but many would recommend that any group outing should always have at least two adults as a minimum.

5. Ensure methods are available for preventing children from becoming lost. Every child should have a whistle and be taught to blow it in successive bursts of three if they are lost. Moreover, children should be taught the Hug-a-Tree and Survive principles. Toddlers should never be left unsupervised, but an additional aid to

keeping track of them is to fix a small jingle-bell to their trousers or shoes. Finally, for nighttime activities, children should be provided flashlights and glowsticks to make their presence clear in the dark.

6. Bring the "Ten Essentials" and teach children about their use: while these items should be brought on all outings regardless of the ages of participants, illustration of their use may serve as a learning opportunity for children and adolescents for undertaking outdoor adventures safely in the future.

7. Ensure all safety equipment and systems are sufficient: depending upon the activity at hand, adequate safety gear and systems should be utilized. Helmets, personal flotation devices (PFDs or lifejackets), and they must be sized for the child appropriately.

8. Children with medical conditions should have adequate supplies available, and their caretakers should be prepared to help them when necessary.

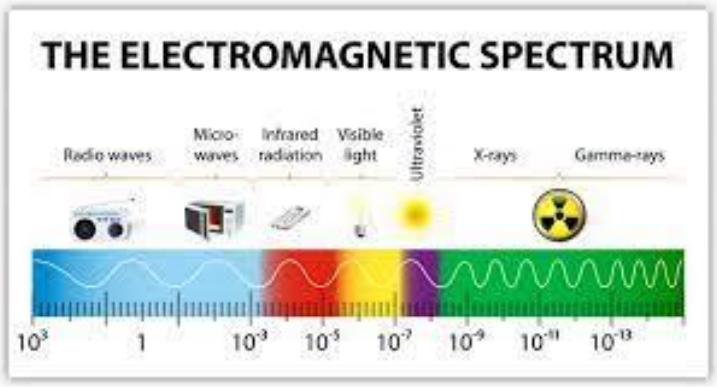
Conclusions

Outdoor recreation and wilderness experiences offer numerous benefits for children and their families. While risks abound in such undertakings, many hazards can be avoided or mitigated. When mishaps occur, wilderness medicine providers and caregivers should bear in mind that children's physiologies are unique, and they may respond to environmental insults much differently than their adult counterparts. In addition, children may become lost easily due to their neurodevelopmental immaturity. Some preparation in the form of "Hug-a-Tree and Survive" presentations, among other preparations, may increase children's odds of survival and recovery. Ultimately, adults must help children navigate the hazards of the wilderness to reap the rewards of outdoor recreation. Preparation and risk assessment are essential to safe adventuring.

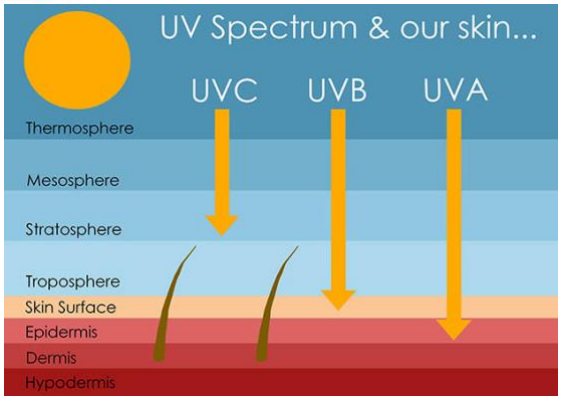
Chapter 11: Electromagnetic Radiation and Sunscreens

It is time to start your hike. You are going up in altitude, and you know to put on sunscreen. The sun is going to be bright. You grab the sunscreen you always have used in the past. It works and you had some left in the bottle from the last time you hiked. You rub it on your face, ears, nose, neck and anywhere that you know is going to be exposed to the sun. You don't want to get a sun burn. And off you go. Sunscreen is an essential part of skin care for anyone going into the outdoors, even if for just a few minutes.

What is interesting about this scenario, however, is that even though people know to put sunscreen on their skin, few people know what it really does, what is in it and how it works There are a lot of myths and misunderstanding about sunscreens. And truth be told, most medical professionals don't know much about this very important compound either. So, let's learn about sunscreens. It all begins with physics!



What is Ultraviolet Radiation? Electromagnetic (EM) radiation comes from the sun. It travels in a wave like manner in little packets of energy called photons. It is these photons that affect our skin. Most EM radiation is not harmful to us. For example, visible light (red, green, blue) is lower in energy and poses no threat to our skin. However, as the wavelength of EM radiation becomes smaller, the photons become more energetic. We start getting worried with ultraviolet (UV) radiation. X-ray and gamma rays can be very harmful because of their high energy. Fortunately for us, X-rays and gamma rays are stopped way up in the earth's atmosphere. Some, but not all the ultraviolet light is stopped in the atmosphere.



What is UVA and UVB? Ultraviolet radiation is often divided into UVA, UVB, and UVB. UVA rays have the longest wavelengths (lowest energy) , followed by UVB, and UVC rays which have the shortest wavelengths (highest energy). While UVA and UVB rays are transmitted through the atmosphere, all UVC and some UVB rays are absorbed by the

Earth's ozone layer. Both UVA and UVB rays can cause damage to the skin. Sunburn is a sign of short-term overexposure, while premature aging and skin cancer are side effects of prolonged UV exposure. By far, the biggest two problems from UV radiation are sunburn and skin cancer. We always need to protect our skin when outside.

How Do Sunscreens Work? Sunscreens are one way to help protect our skin from ultraviolet radiation. There are two types of sunscreens, physical sunscreens, and chemical sunscreens. Physical sunscreens are placed on top of the skin. Chemical sunscreens are absorbed into the skin. Both physical and chemical sunscreens mostly work by absorbing UV radiation and converting it to heat. Both types of sunscreens have electrons that can be excited to higher energy levels by UV radiation, then when these electrons fall back down to their original energy levels, they release their energy mostly as heat. Physical sunscreens scatter and reflect a small amount of UV radiation, somewhere around 10%. So, they give a little extra protection.

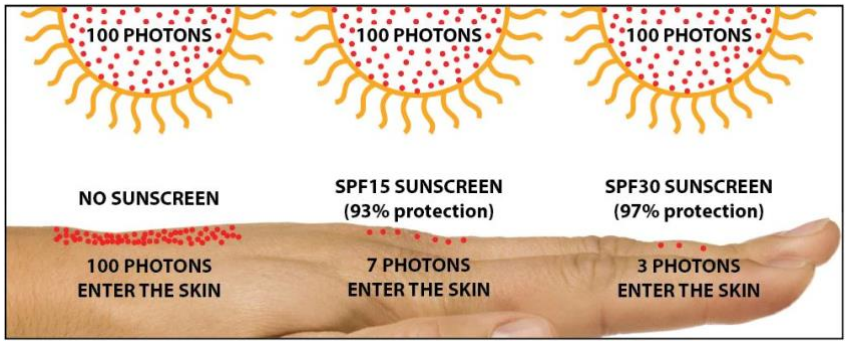
What is in Sunscreens? There are currently only two FDA approved physical ingredients for physical sunscreens, titanium dioxide and zinc oxide. Some of the most common ingredients for chemical sunscreens have some issues.

Avobenzone: This is the most used UVA chemical filter found in chemical sunscreens. This ingredient is unstable, meaning it quickly degrades in energy from the sun. Frequent application is essential.
Octinoxate: This compound minimizes DNA photodamage as it absorbs UV-B rays from sun. This chemical filter is absorbed rapidly into the skin and is a known endocrine disruptor that can affect thyroid function.
Octisalate: While Octisalate helps absorb UVB rays (but not UVA rays), it's also a penetration enhancer, meaning it increases the amount of other ingredients that pass into your skin. If a chemical sunscreen contains hazardous ingredients, they are more likely to pass into the body when Octisalate is present in the formula.
Oxybenzone: Despite the threat it poses to the body, oxybenzone is one of the most common chemicals found in sunscreens. This chemical absorbs UVB and UVA rays, but it increases the body's production of free radicals after sun exposure. It's also been implicated as a hormone disruptor and may affect the production of estrogen in the body. Some sunscreens are dropping this compound.
Octocrylene: This chemical UV filter can absorb both UVB and UVA rays, but like Oxybenzone, it also increases the production of free radicals after being exposed to the sun.

How Strong are Sunscreens? There are two rating systems to evaluate how 'strong' sunscreens are.
1*. PA Grading System:* The PA grading system was established in Japan and is meant to inform users of the level of protection from UVA rays. The PA rating system was adapted from the Persistent Pigment Darkening (PPD) method. This test uses UVA radiation to

cause a persistent tanning of the skin. PPD is tested on a variety of people, all exposed to UVA light. Researchers then compare the results between unprotected and protected skin. In theory, a sunscreen with a PPD rating of 10 should allow an individual to handle 10 times as much UVA exposure. Currently, only five countries utilize UVA testing: Japan, the United Kingdom, Germany, the United States, and Australia. PA+ means your sunscreen or cosmetic provides some protection against UVA rays, PA++ provides moderate protection, and PA+++ offers the best protection of the three. Recent advancements have seen the introduction of PA++++ products in certain countries.

2. *Sun Protection Factor SPF:* SPF stands for Sun Protection Factor, and this measurement indicates how well and for how long your sunscreen will protect your skin from the sun's UVB. If going without sunscreen allows 100 photons of radiation to enter your skin, using SPF15 sunscreen, offers 93 percent protection from the sun's rays, only 7 of those photons would be able to penetrate your skin. That protection is improved by using SPF 30 sunscreen, which protects against 97 percent of the sun's rays so only three photons would penetrate your skin. SPF is a measure of how much UV radiation is required to produce sunburn on protected skin relative to the amount of solar energy required to produce sunburn on unprotected skin. As the SPF value increases, sunburn protection increases. So, it is a measure of erythema. If you burn in 10 minutes and use an SPF of 20, you will burn in 200 minutes. A person with very fair skin should wear at least SPF 30 anytime they head outdoors, whether they're spending 15 minutes or two hours exposed to the sun's rays. In contrast, a person with very dark skin is less likely to burn and may require only SPF15 to protect their skin for up to four hours. Reapplication is the only way to keep your skin consistently protected, whether you're spending an hour or four hours in the sun. Higher SPFs doesn't necessarily provide all that much more added protection. Going from an SPF 15 (which screens out 93 per cent of UVB rays) to a 30 (which screens out 97 per cent), does make sense though. What tends to happen is that users confuse the higher-rated SPF with how long the sunscreen lasts on your skin. A higher SPF or Zinc Oxide content needs to be reapplied at the same intervals as you would for a lower option sunscreen. This in turn creates a disconnect with how effective the higher percentage of products are since they get incorrectly applied and cannot shield you the way they should.



What is a Broad-Spectrum Sunscreen? Broad spectrum SPF refers to sunscreens that protect the skin from both UVA and UVB rays. Even with a high SPF, if a sunscreen isn't broad spectrum, you won't be protected from all UVA rays. The current FDA SPF numbering system only identifies the amount of UVB protection a sunscreen product provides, not the amount of UVA protection. For sunscreens to be labeled as broad

spectrum, the FDA requires sunscreen products to now go through a battery of tests to prove they protect from all UVA and UVB rays. It's important to protect from both types of UV rays because they damage your skin differently.

Think of it this way:

- UVB has a B for "burning" – these rays cause sunburn, aging, and potentially skin cancer
- UVA has an A for "aging" – these rays cause wrinkles and potentially skin cancer (although less than UVB) after repeated exposure. UVA rays make up more than 90% of all UV radiation, and penetrate clouds and glass, year-round.

Broad spectrum sunscreens include combinations of ingredients that protect from both types of rays. Keep an eye out for a combination of zinc oxide, Octinoxate, Octisalate and titanium dioxide. Different combinations of these ingredients will protect against both UVA and UVB rays for full protection.

Do Sunscreens Prevent Skin Cancer? When used as directed, sunscreens are proven to decrease (not prevent) the risk of skin cancers and skin precancers. Regular daily use of SPF 15 sunscreen can reduce your risk of developing squamous cell carcinoma by about 40 percent and lower the melanoma risk by 50 percent. There's a danger in assuming that putting on sunscreen is by itself enough to protect you against the cancer. Many studies have demonstrated that individuals who use sunscreen tend to stay out in the sun for a longer period, and thus actually increase their risk of skin cancer.

There's a danger in assuming that putting on sunscreen is by itself enough to protect you against the sun.

How Do I Protect My Skin Completely?
1.Use sunscreen even if it's cloudy.

2. Apply at least one ounce of sunscreen at least 15 to 30 minutes before going outside.

3. Use a lip balm that contains sunscreen.

Uses for this sunscreen:

- Helps prevent sunburn.
- If used as directed with other skin protection measures decreases the risk of skin cancers and early aging caused by the sun.

4. Choose a broad-spectrum sunscreen that protects against both UVA and UVB radiation.

5. Reapply sunscreen every two hours.

6. Keep babies younger than 6 months old completely covered and in the shade. Sunscreens are not appropriate for children under 6 months.

7. Limit the amount of time you're in the sun between 10:00 AM and 4:00 PM. This is when the sun's rays are the most intense.

8. If possible, wear a long-sleeved shirt and long pants.

9. Accessorize with a hat that shades your face, neck, and ears and a pair of sunglasses.

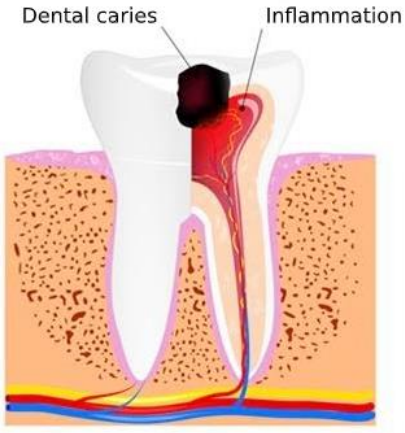
Chapter 12: Dental Problems on the Trail

Dental problems are common in biking and provoke considerable anxiety. Most people don't even think to learn about dental problems and procedures beforehand. This chapter is to teach dental first aid, to help get a biker back home where a dentist can take care of the dental problem.

Pulpitis (Tooth Ache)

Inflammation of pulp is the primary cause of most toothaches and is often the precursor for more serious dental and facial infections. The pain can range from mild to debilitating and can be steady or intermittent. Inflammation can arise from bacterial entry into the pulp from tooth decay, also called a cavity. Sometimes a filling has been placed near the pulp, and this can cause pain. Trauma can cause inflammation of the pulp, which causes pain. Early on, the tooth will be sensitive to a stimulus such as heat or cold, or sweet or sugary food placed on the tooth. Sometimes the tooth will frequently remain achy or painful after the stimulus has been removed.

Signs and symptoms of pulpitis may range from mild, intermittent pain to severe, constant pain. It will usually have sensitivity or pain to stimuli such as cold, hot, sweets, or tapping. In the early stages, it may be difficult to identify which tooth is causing the pain. In these cases, the tooth may look normal, or have a small cavitary lesion. In later stages, tooth decay may be obvious. The treatment of pulpitis is first to remove any irritants or debris, usually by swishing the mouth with warm water. You can give Ibuprofen, which is great in for reducing pain. All bikers with pulpitis should see a dentist upon returning home.



When a Filling Falls out

When fillings or crowns fall out, the tooth can hurt. To correct the situation until you can get to a dentist, you should first remove any debris in or around the tooth. You can rinse the mouth or try to pick debris out if necessary. Once this is done, you need to fill the hole in the tooth with some temporary filling material.

There are two products that you can choose to put in your first aid kit.

- **Cavit** comes pre-mixed and will harden once placed in the mouth. Cavit can be thinned, if necessary, by mixing it with petrolatum jelly (Vaseline).
- IRM comes in a powder/liquid form that requires mixing. The advantage of IRM is that it can be mixed to any consistency.

Dental Trauma

Injuries to teeth are common during biking races and practices. Trauma can be isolated to the tooth, but it often involves the soft tissue and supporting tissue as well. Clean the region well to remove blood or debris.

Chipped tooth

These are common in biking sports where almost anything can strike the mouth. When you look at it, you will see an obvious chip in the tooth. The pulp is usually not exposed, but it might still be sensitive to stimulus (hot, cold, sweets). The treatment is pain management. You can smooth sharp edges by placing temporary filling (IRM, Cavit, soft wax, or tape) over the tooth. Usually, you can wait until you get to the dentist.

Tooth Fracture

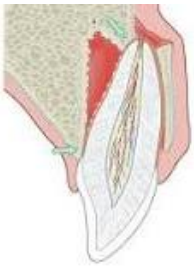
A fracture is where a very large part of the tooth is broken. When you examine the area, there will be a loose piece of tooth, and there will be pain or irritation on biting. The treatment is to remove any loose fragment(s), and then cover the tooth with a temporary filling. This will help with pain,

but you will likely need to give Ibuprofen. A temporary filling will help with the pain, but a dentist needs to repair this.

When a tooth is Knocked Loose

Trauma to the mouth may not fracture a tooth. Instead, damage may occur to the supporting structures around the tooth, in which case the tooth will be displaced from its normal position. The following are possible scenarios that can affect teeth and supporting tissues.

Subluxation (loose tooth)



Subluxation is where the tooth has increased mobility but has not been displaced from its original location. Symptoms may vary depending on the severity of injury to the supporting structures. Treatment consists of a soft diet, rest, and NSAIDs for pain management, if necessary. When injured teeth are painful, temporary splinting may ease pain and enhance the ability to eat. A dentist will need to realign the tooth.

When a Tooth is Knocked Out

Having a tooth knocked out on a bike ride is not uncommon. Bikers can fall on their faces. Quick action is needed to increase the survival of the tooth. The longer the tooth is out of the mouth, the less the chance for survival of the tooth.

The best thing to do is to try to put the tooth back in its socket, so be careful of the tooth. A tooth can survive with a high rate of success if reimplanted in the first 20 minutes after the accident. This isn't always practical when you consider the amount of time needed to assess the situation, secure the trail, survey the injured biker, find the tooth, prepare the tooth and socket, and get the tooth back into the socket. While not ideal, the prognosis is still good if this can all be done within the 1st hour. When handling the tooth, do not scrub, scrape, disinfect, or let the root surface dry out. Rinse the tooth with water to remove debris. Remove clotted blood from the socket, using gentle irrigation and suction. Replace the tooth gently with steady pressure to displace any accumulated blood. This will hurt. The tooth will then need to be splinted in place. This may be difficult but necessary. It may be necessary to improvise with material on hand. Fishing line or even floss could be bonded to splint teeth.

TRANSPORT SOLUTIONS

If you cannot reimplant the tooth, take it to the dentist as quickly as possible. Here is a quick rundown of what is good to use and what you should avoid. Unfortunately, there is not a good medium that is also commonly taken into the activity.

The Best Solutions

Hank's Balanced Salt Solution	While this is probably the best medium, it is mostly used in research application and not readily available. There are two companies that have such a kit (Save-A-Tooth and EMT), A tooth will last 24 hours in this solution.
Milk	Milk is everywhere and does an excellent job in maintaining a knocked-out tooth. Milk will help a tooth to last for about 6 hours. Whole milk might be best, but any milk will do including rice milk and almond milk.

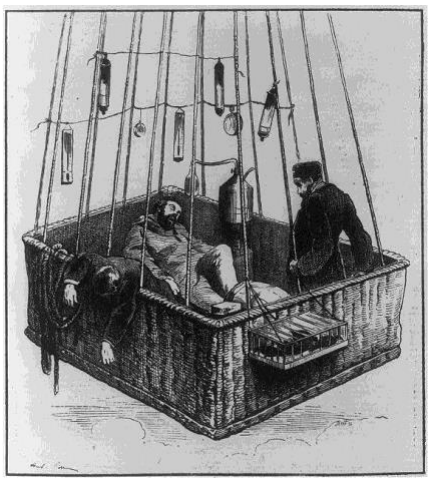
Not Great Solutions

Salt water	This is great for irrigating but not good for tooth storage. It can be found in some First Aid Kits.
Saliva	Saliva will do in a pinch, but it has some limitations. There are enzymes and bacteria in our saliva that overtime will damage a tooth. This will protect a tooth for about 30 minutes.

Poor Solutions

Water	Water destroys the cells on the tooth. It can be used to rinse the tooth but isn't a good storage medium.
Sports Drinks	Sports drinks are not good and can damage a tooth.

Chapter 13: Altitude Illness



What would happen to you if you were taken immediately to the summit of Mt. Everest? The answer is you would pass out, and likely die within minutes. A similar scenario occurred in the balloon flight of the 'Zenith' in 1875. At that time, ballooning had progressed to where high altitudes were obtained, and scientists were going to dizzying heights to discover the effects of 'thin' air. Three French scientists wanted to go higher than anyone had before. When they reached the 'death zone' of about 27,000 feet (8,200 meters), they passed out. One of the scientists awoke to find the other two were dead. The Zenith crashed to the earth outside of Ciron, France. The two men had died of altitude illness.

WHAT IS ALTITUDE ILLNESS?

Most people are unaware that ascending to altitude includes an inherent risk of becoming ill and even dying. There are many tragic stories of people dying on the mountain just because they were high in elevation. About 100 years after the flight of the Zenith, in 1978, Messner and Habler ascended Mt Everest without oxygen. They went as high as the Zenith, yet, they survived. The difference is that they allowed time for their bodies to acclimate.

The problem is *not* a lack of oxygen at altitude, as the oxygen content of the atmosphere is stable up to 10,000m+ (32,800 ft). The issue is that the pressure of oxygen decreases logarithmically as altitude increases, which causes hypobaric hypoxia (low oxygen pressure). This is the reverse effect of diving, where the pressure of oxygen increases dramatically. Altitude illness is extremely rare at elevations below 2,000m (6,500 ft).

In simple terms, we need the pressure to push oxygen into our bloodstream. If there is not enough pressure when a person is at altitude, then the body will reduce the pressure inside the vessels by lowering the levels of carbon dioxide, by hyperventilating. Unfortunately, hyperventilating removes the CO2 that drives us to breath and eventually lowers are breathing. Rate. To allow us to continue breathing fast, our kidneys secrete bicarbonate, causing people to urinate more at altitude.

Swelling

The most severe symptoms of altitude sickness arise from edema, or fluid accumulation, in the body. This can occur anywhere, including the tissues under the skin. The most severe consequences of this swelling happen in the brain and the lungs.

At very high altitude, swelling in the brain is called acute mountain illness (**AMS**), which progresses as the edema increases to be called high altitude cerebral edema (**HACE**). As edema forms in the lungs, it is called high altitude pulmonary edema (**HAPE**).

The physiological cause of altitude-induced edema is not conclusively established. It is currently believed, however, that **HACE** is caused by opening of cerebral blood vessels, resulting in higher blood flow and, consequently, higher pressures in the vessels in the brain. On the other hand, **HAPE** may be due to general vessel constriction in the lung circulation which, with constant or increased blood flow out of the heart. This also leads to increases in lung vessel pressures.

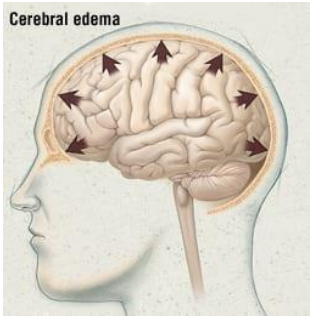
Acute Mountain Sickness (AMS)

Medical history is the key to diagnosing Acute Mountain Sickness (**AMS**) because there are no specific physical exam findings. It is vital to assess the rate of ascent and the total elevation gain. AMS is a common. It is diagnosed as a headache, and at least one of the following symptoms:

- Dizziness or lightheadedness
- Fatigue or weakness
- Nausea/vomiting/anorexia
- Insomnia

The most significant risk factors for AMS are a prior history of AMS, fast or high ascents, and obesity. Men and women and children are equally susceptible.

High Altitude Cerebral Edema (HACE)



As edema in the brain increases, symptoms become more profound, and AMS progresses to HACE, a life-threatening disease. HACE is defined as severe AMS symptoms with additional apparent neurologic dysfunction:

- Poor muscle control: this is the most common sign of HACE
- Altered level of consciousness
- Severe lack of energy: While the boundary between AMS and HACE can be blurry, HACE almost never occurs without AMS symptoms first. The progression of AMS to coma typically occurs over 1 – 3 days. HACE and HAPE are often present simultaneously.

High Altitude Pulmonary Edema (HAPE)

HAPE usually evolves over two to four days after ascent to altitude. The criteria for HAPE diagnosis are symptoms of at least two of the following.

- Shortness of breath at rest
- Cough
- Weakness or decreased exercise performance
- Chest tightness or congestion

The primary symptoms are shortness of breath at rest, cough, and exercise intolerance. The initial sign will often be a marked decrease in exercise tolerance in an individual as compared to previous days. Occasionally, frothy pink sputum is produced, but this is usually later in the illness. Mild cases may resolve within hours after a descent. In contrast, severe cases may progress to death within 24 hours, particularly if descent is delayed.

Prevention

Slow ascent is the safest method to facilitate acclimatization and to prevent any altitude illness. Current recommendations for climbers without experience at high altitude are to spend two to

three nights at 2500 – 3000 meters before a further ascent. Increases of greater than 600 meters in sleeping altitude should be avoided. One should consider an extra night of acclimatization for every 300 – 900 meters of altitude gain. Medicines can help but are no substitute for a gradual ascent.

AMS/HACE
There is a medicine called acetazolamide that can help. But going up slowly is a better way to prevent altitude illness. This medicine works by increasing the breathing rate. Since, during a hike, people are already breathing fast, its effects are felt mostly at night during sleep.

HAPE
Prevention for HAPE is to limit the ascent rate to no more than 350 meters (1155 ft) a day.

Treatment

AMS
The treatment for acute mountain sickness (AMS) is to discontinue ascent and rest. Descent is the best treatment.

HACE
The treatment for HACE is IMMEDIATE descent (almost always with assistance). This is imperative and should not be delayed. Even modest elevation losses can be helpful. In addition to descent, administering a medicine called dexamethasone can be used as you go down. Recovery with prolonged problems can last for weeks. Most who survive eventually fully recover neurologically.

HAPE
The treatment for HAPE is IMMEDIATE descent. All that may be required is 500 to 1000 meters of descent before improvement is observed. The patient should rest after a descent. No intervention should delay an opportunity to descend.