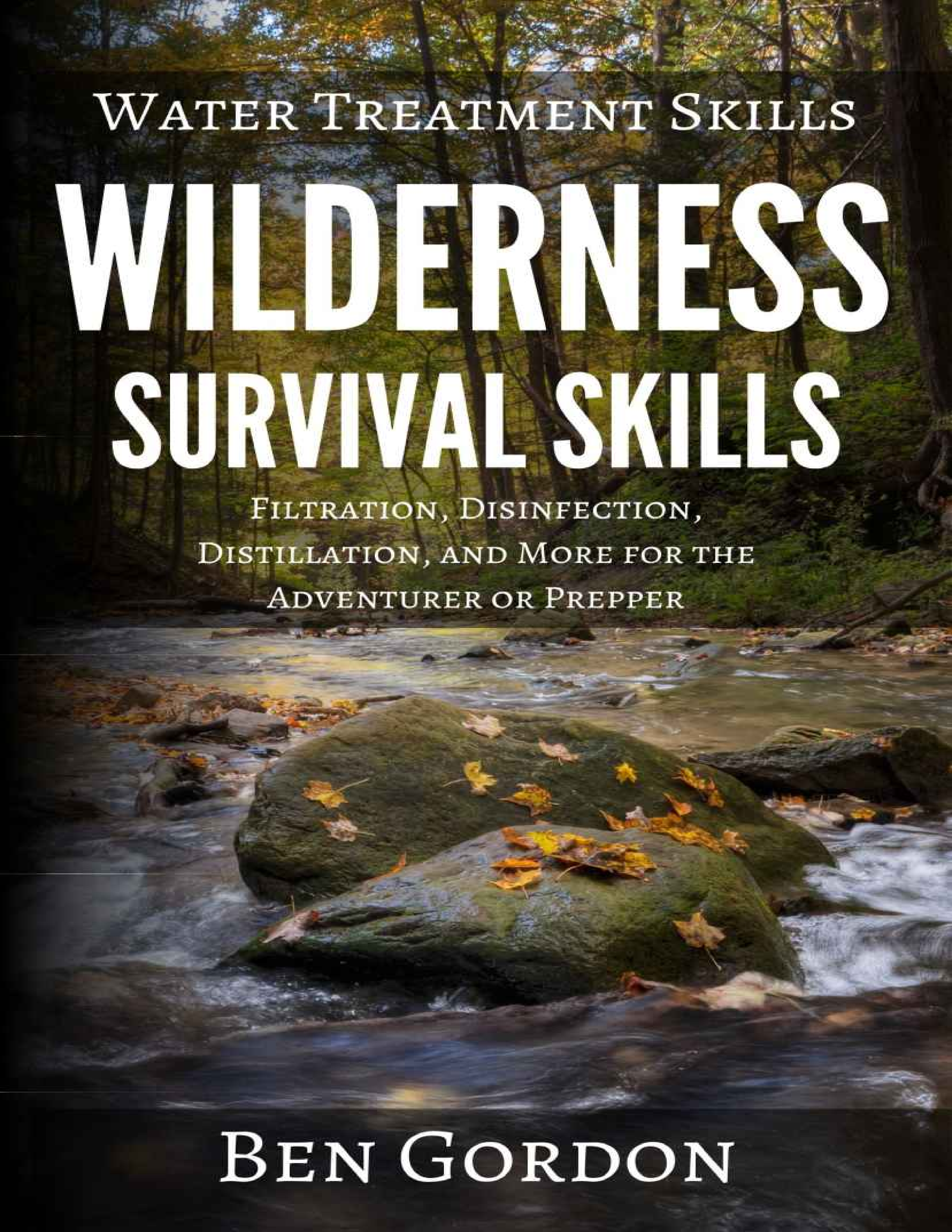

WATER TREATMENT SKILLS

WILDERNESS SURVIVAL SKILLS

FILTRATION, DISINFECTION, DISTILLATION, AND MORE FOR THE ADVENTURER OR PREPPER

BEN GORDON

WILDERNESS SURVIVAL SKILLS

Drinking Water Treatment for the Adventurer or Prepper

Ben Gordon

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INTRODUCTION

I want to thank you for downloading the book, “Wilderness Survival Skills: Drinking Water Treatment for the Adventurer or Prepper”.

I take it for granted that you understand the importance of water to our lives. Water is absolutely critical to all functions of our body, and severe permanent damage can very quickly happen without it. The “Rule of 3” is frequently quoted as saying people can survive, on average, up to about 3 days without water, but this varies wildly. There are reports that a man survived locked in an Austrian jail cell, licking condensation of the walls, for eighteen days, but in a hot and arid climate, permanent damage can begin in hours.

However, drinking any old water you happen on in the woods isn’t a great course of action either. Most water sources, even those that look and smell great, are rich with microorganisms that can rapidly trigger vomiting, diarrhea, and nervous system collapse. No matter where you adventure, and even if you’re not an outdoorsy sort of person, knowledge of what to do with found water is so critical it should be taught to children.

It has been my experience that the internet can teach us a great many things about the world around us, including how to survive in less-than-ideal situations. Information on building fires and which knife steel is superior abounds, but one topic that wants for more coverage, in more detail, is the procurement of drinkable water.

Many blogs and survival manuals present a few methods for treating water in the outdoors, but the details are usually hazy, the merits discussed are often superficial, and the limits of each technology are often blatantly omitted. This has resulted in a great many people in the survival community becoming unconsciously incompetent, a condition far more dangerous than knowing nothing about water treatment in the first place.

My goal in this writing is to rectify this situation, putting my engineering education to work. Water treatment is my secondary specialty, and I’ve been interested in survival skills since I was seven years old. For ten years, I worked as a camp counselor, teaching survival skills and environmental education to elementary students and teenagers. I have been part of a search and rescue team, and was a certified wilderness first responder for a time. Now I work as an engineer, and write to bring together my scientific and outdoorsy interests.

Most of my knowledge of the details of municipal drinking water treatment facilities comes from classes taken with an esteemed professor, recipient of the Order of Service Merit from the President of South Korea for his outstanding contributions to a monumental river restoration project in that country. I am grateful to him for his teachings.

Thanks again for downloading this book, I hope you enjoy it!

CONTAMINANTS

In order to make raw water safe to drink, we need to first understand what dangers the water source holds. Whether treating water in the backwoods or in a modern industrial drinking water treatment facility, the steps needed to clean and purify water depend on the contaminants in the source.

The United States Environmental Protection Agency (EPA) is the regulatory body charged with defining the effluent quality needed for municipal and commercial water treatment. These limits are often expressed in terms of milligrams per liter of water, levels far below what we can hope to achieve with improvised treatment methods, but they can help guide us in understanding what kinds of dangerous contaminants occur. To put it plainly, **we will not be able to make water totally safe in the backcountry**, only make it less unsafe.

The EPA has two sets of drinking water standards, primary and secondary. Primary drinking water standards are mandatory, for the protection of health and safety. Secondary standards are recommendations to help control odor, taste, and prevent undue wear on pumps and other machines. Water that meets all primary standards is “safe to drink”, per the EPA, even if it does not comply with all secondary standards. This water could taste, look, and smell terrible, but still be safe. On the other hand, water that looks and tastes wonderful could be very, very dangerous if it meets all the secondary standards, but fails to meet even one of the primary ones. However, our senses can still be helpful, as many biological contaminants do make water look cloudy and smell awful. In general, clear, fast-moving water will be of better quality than smelly stagnant water, but it should still undergo at least some treatment.

The primary drinking water standard contaminants are divided up into six categories: microorganisms, disinfectants, disinfection byproducts, inorganic chemicals, organic chemicals, and radionuclides. Many of these are undetectable without special equipment, even at dangerous concentrations.

Microorganisms include cryptosporidium, giardia, legionella, and E. Coli as directly limited, as well as controls on the total turbidity (water cloudiness) as an indirect control on the many other detrimental microorganisms. In fresh surface water sources like lakes and streams, microorganisms are the most likely contaminant, and as such will be our major focus. Microorganisms are only harmful when present and alive in drinking water. Filtration (through a fine enough filter) and settling can remove them from the water, or they can be killed off with heat, chemical disinfectants, or enough exposure to ultraviolet radiation (like sunlight).

Chemical disinfectants like chlorine or iodine are molecular poisons. They excel at killing off microorganisms, but are also hazardous to human health, so limits exist on their concentrations when the water leaves the treatment plant for the distribution network. Unfortunately, the byproducts of chemicals like chlorine tearing microbes apart are also dangerous, though in a less immediate sense than Legionnaire’s Disease. “Trihalomethanes”, methane with three of the hydrogen atoms replaced with chlorine or other halogen atoms, have been recognized as causing cancer. No one wants to drink carcinogens, so disinfection byproducts are limited as well. These are unlikely to be encountered in the backcountry, but could well be found downstream of overzealous water and wastewater treatment facilities.

Chemical disinfectants rarely occur naturally, but can be introduced into water by some industrial and agricultural activities. The most likely source in the backcountry is those awful iodine tablets. They don’t just smell and taste bad, they actually leave behind residuals that can have adverse health effects, though properly following the instructions with the neutralizing tablet helps limit them. Disinfectants are normally reacted out of the water chemically, placing them firmly outside the scope of the average improvising outdoorsman or outdoorswoman. None of the techniques discussed in later chapters will be very effective in their removal, short of full-on distillation operations, or the limited success that can be had from adsorption.

***As a side note:** Some small amount of chlorine is typically left in US municipal water to kill off any microbes that make their way into the pipes. In much of the European Union, disinfection of drinking water is instead accomplished by running the water under extremely bright ultraviolet (UV) lights, and no residual disinfectant is added. Both approaches have their drawbacks, as the "purer" European water is much more vulnerable to microbes that may infiltrate the distribution system, while the American chlorinated water will transform those microbes into carcinogens. This may help explain the higher occurrence of Legionnaires' Disease in Western Europe, versus the higher cancer rate in the US.*

The inorganic chemicals group is made up of arsenic, heavy metals, and nitrates/nitrites. For the most part, these will be difficult to detect on your own unless they are present in very high concentrations (I once lived in a house with well water that was very high in nitrates, and once the water was softened, it smelled like a cured ham). Heavy metals and arsenic are usually leached out of naturally-occurring deposits that the water interacts with, either over veins on the surface, or permeating through subsurface deposits. Nitrates and nitrites tend to occur from fertilizer runoff. Most of these are tough to recognize on your own, but the good news for survival situations is that many of them take time to build up to toxic levels. They *hopefully* won't do you in as quickly as massive dehydration brought on by dysentery, which is helpful, as options for dealing with them in the backcountry are very limited. Avoidance is the preferred method, but distillation can work for many of them, as well as adsorption to a limited extent.

Organic chemicals, like benzene and PCBs, are usually introduced to water sources by industrial or agricultural operations. Proper removal requires a laboratory and some knowledge of organic chemistry, so we won't go very deep into them. Some fall into the category of Volatile Organic Compounds (VOCs), and give off very strong odors that can warn of their presence, but others are stealth killers. Usually not a concern unless there is heavy industrial/agricultural activity in the area, avoid drinking from water sources downstream of mining operations especially. Some of these can be driven off by boiling, as they have a lower boiling point than water, but not all. Some can also be adsorbed by activated charcoal.

The final category, radionuclides, is the scariest of the bunch. Without a Geiger Counter, you will have no idea they're present, but in high concentrations or prolonged exposure to low concentrations, they're still quite lethal. Caused by water flowing over and around natural deposits of uranium and the like, our only hope is avoidance. Get to know the geology of your preferred outdoor recreation area. Make a point of avoiding areas with large deposits of uranium and other radioactive ores (usually a good idea in any case), and surface water sources will be unlikely to pose much threat. However, many more groundwater sources have high levels of radionuclides, so be aware of the threats in your area. A friend from New Hampshire mentioned that up that way it's common practice to have regular testing of any private well tap water.

Additionally, it's not a good idea to drink salt water. Though not specifically listed in the primary drinking water standards above, drinking salt water will kill you more quickly than water contaminated with many of the contaminants we've already talked about. Your body will suck pure water out of your cells to try to dilute down the salts in seawater, which will dehydrate you very quickly. Kidney failure is also quite common with seawater ingestion cases, as the kidneys go into overdrive trying to filter out the high concentrations of a whole trove of salts and minerals. The best way to deal with the salt is some form of distillation.

Most outdoor enthusiasts don't carry fully-stocked water quality test kits in the field, nor do we know how to do anything meaningful with them. Our best way to be prepared is to be informed. Ask around about the water quality issues anywhere you plan to spend some time, even if it's just for a day trip. Many park rangers will be quite knowledgeable of the common contaminants in their area, and can even make recommendations on what filter mesh size is required to extract the most common microbes. Pay attention in visitor's centers, as many will have signs giving the same information. The internet is also a treasure-trove of information for popular outdoor travel spots.

Keep in mind that water will almost never have just one contaminant or class of contaminants. Seawater is rich in minerals and microorganisms. Groundwater is much more likely to be contaminated with heavy metals and radionuclides. Surface fresh water often has microorganisms of all sorts, and may have other issues as well. Conventional drinking water treatment consists of several stages designed to settle out sediment, filter out remaining small contaminants, and disinfect what's left. To this framework, many distinct auxiliary processes are added to neutralize the particular threats of the source water, such as pH adjustment, heating to remove VOCs, or chemical treatments to reduce chemical and radiological contaminants.

Especially with improvised treatment methods, it's important to use as many methods as feasible to ensure that the water is as clean as possible. Filtered and boiled water can still be rich in arsenic and lead. Each treatment method only works on some of the threats, and it is impossible to know without testing exactly which threats were in the water to begin with. **We can only do our best with what is available and hope it is enough.**

FILTRATION AND SETTLING

Filtration and settling target those contaminants that can be physically removed, because they are suspended in the water, rather than dissolved. Take a warm glass of water and mix in a little salt. Stir it up, and it dissolves. You can't filter that out, or wait for it to settle. But if you add enough salt, you saturate the water, and no more salt will dissolve, unless you heat the water up. To get the salt back, you'd have to resort to other means.

Now take a bottle of water and mix in some dirt. Shake that up, and it'll go cloudy, but if you wait long enough, most of the dirt will settle back to the bottom. The dirt was suspended, rather than dissolved. The finer the particles that are suspended, the longer they take to settle.

Some suspended particles won't ever settle out on their own. They're still physically separable, but they have enough electrostatic charge that they repel each other and can't settle out. To overcome this, conventional water treatment plants introduce "flocculants", substances like alum powder (you can pick this up in the spice section of your local grocery store, it's used for pickling as well) that are oppositely charged, helping the existing particles attract each other, forming large clumps or "flocs". These clumps then settle out much faster.

Conventional water treatment plants mix in flocculants and other chemicals for treatment, then flow the water nice and slow through settling tanks to let the big stuff come out before it hits the filters. Filter beds, usually made up of anthracite coal pieces about 1 mm in diameter, sand at about 0.5 mm, and garnet sand at about 0.3 mm, act as giant strainers to remove the rest of the solids. The water then heads on to disinfection.

Microbes are the major target of this stage of treatment, with sizes of the typical bad actors ranging down to about 3 microns, the size of *cryptosporidium* spores. There's a whole host of nasty microbes that need to be dealt with, but as *cryptosporidium* is the smallest, that's the usual target. Note that I mentioned the finest sand in conventional water filtration plant filters is about 0.3 mm in diameter, which is 300 microns. How does that sand filter out particles 100 times smaller? It all comes back to the flocculation, which also serves to coagulate microbes into larger clumps.

Backpackers don't usually flocculate or settle their water, so their filters need to be much finer. The LifeStraw my wife got me for Christmas claims to filter out particles down to 0.3 microns, but the "pore size" or "mesh size" varies from filter to filter. Some of the cheaper or older ones don't get down fine enough to catch everything, but depending on the local microbes, they may be good enough.

The penalty to pay for such fine pores is excessive backwashing. Just like the strainer basket in a sink gets filled up with junk, filters will slowly lose flow rate / take more pressure to move water through over time. The stuff you're filtering out accumulates in and on the filter, and needs to get flushed out. Oftentimes this is done by flushing clean water back through the filter or manually cleaning the surface. Neglect to do this with a backpacking filter, and not only will you work way harder than you need to, you might create enough pressure to break the filter.

Improvised Filtration Applications

Improvised field filters simply won't get the microbes out, no matter how well constructed they are. Even with the aid of flocculants, I wouldn't count on anything constructed to do the job without some disinfection.

Trying to filter out small pathogens like *cryptosporidium* (0.006 mm) with even the finest of sands (0.075 mm) is every bit as effective as trying to use soccer balls (220 mm) to strain out large sand (1 mm).

That's not to say that they're worthless though. Improvised sand filters can easily remove sediment and other suspended solids, greatly improving the aesthetics of the water. Sediments can make you sick in their own right, so minimizing their consumption is a plus. Clear water is much easier to disinfect as well, so it does pay to filter.

The most common backwoods filtration system you'll find online these days consists of a two-liter soda bottle with the bottom cut off, packed with grasses and twigs at the bottom, then a layer of charcoal, followed by gravel, and on up to progressively finer sands. They can also be constructed as a series of cloths filled with each layer of filter media suspended from a tripod. Filters like these can do a great deal to clarify water, and also attempt to make some use of adsorption in the charcoal. Do note that charcoal from a campfire is not *activated charcoal*, the preferred adsorption media. More on adsorption in its chapter later.

An often-overlooked filtration method, dating back at least as far as biblical times, is riverbank filtration. Given an appropriately sandy soil type, the banks of the river can be used to filter out sediment and suspended solids. All this takes is digging a hole a short distance from the body of water, and allowing the water to percolate up into the hole and settle, just like kids do at beaches everywhere. After a short break-in period, the water in the hole will be cleaner and clearer than that in the river itself. The hole can also serve double duty for a solar distillation setup (solar still), especially with saltwater.

Both of these improvised methods do improve the water quality, but remember not to jump straight to drinking this improved water.

It’s better than direct from the surface water source, but can still be crawling with enough pathogenic microbes to make you sick for weeks. If at all possible, disinfect this water next.

* * *

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DISINFECTION

Water that looks crystal clear can easily harbor a number of pathogenic contaminants, undetectable to the unaided eye. In fact, surface water sources accessible to the survivalist are likely crawling with diarrhea-causing organisms almost anywhere in the world. Luckily inactivating these pathogens is not necessarily difficult. There are three typical ways to kill off harmful microbes: **chemical, heat, and radiation (usually ultraviolet)**.

Do bear in mind that disinfection is only effective at inactivating microorganisms. It does not help to remove any sort of contaminant, or render anything else safe.

Chemical Disinfection

Chemical disinfectants have long been popular with backpackers, the military, and survivalists. Often associated with a strong taste and/or smell, chemical disinfectants have another lesser-known detrimental effect - they produce carcinogens as a byproduct of infection. While carcinogens are obviously not desirable to ingest, in a short-term survival situation, it may become a choice between carcinogens or death by dehydration.

Trihalomethanes, known carcinogenic material, are produced as a result of iodine, chlorine, or bromine ripping organic material apart and bonding with it. This is why many municipal water supplies are disinfected by other means, though in the US the risk of Legionnaires and other harmful pathogens infiltrating the distribution system is viewed as the more urgent risk, so a chlorine residual is required by law. Plants that disinfect with UV lights are still required to add a small dose of chlorine into the water before it hits the municipal supply lines.

Iodine tablets, known for their awful taste, have been a fixture in survival kits for decades, but they're starting to be replaced with much more palatable chlorine dioxide tablet products. When using either option, make sure to read and carefully follow manufacturer's instructions for best results.

Some survivalists and preppers stockpile bleach as a potentially very dangerous method of disinfection, using a small dose per gallon. The below instructions and table regarding the use of bleach for disinfecting drinking water are copied directly from the US EPA's website, and can be found at https://www.epa.gov/ground-water-and-drinking-water/emergency-disinfection-drinking-water

-- Start EPA website quoted section --

> ***Disinfect water using household bleach**, if you can't boil water. Only use regular, unscented chlorine bleach products that are suitable for disinfection and sanitization as indicated on the label. The label may say that the active ingredient contains 6 or 8.25% of sodium hypochlorite. Do not use scented, color safe, or bleaches with added cleaners. If water is cloudy, let it settle and filter it through a clean cloth, paper towel, or coffee filter.*
>
> - *Locate a clean dropper from your medicine cabinet or emergency supply kit.*
> - *Locate a fresh liquid chlorine bleach or liquid chlorine bleach that is stored at room temperatures for less than one year.*
> - *Use the table below as a guide to decide the amount of bleach you should add to the water, for example, 8 drops of 6% bleach, or 6 drops of 8.25% bleach, to each gallon*

of water. Double the amount of bleach if the water is cloudy, colored, or very cold.

- *Stir and let stand for 30 minutes. The water should have a slight chlorine odor. If it doesn't, repeat the dosage and let stand for another 15 minutes before use.*
- *If the chlorine taste is too strong, pour the water from one clean container to another and let it stand for a few hours before use.*

Volume of Water	***Amount of 6% Bleach to Add****	***Amount of 8.25% Bleach to Add****
1 quart/liter	*2 drops*	*2 drops*
1 gallon	*8 drops*	*6 drops*
2 gallons	*16 drops (1/4 tsp)*	*12 drops (1/8 teaspoon)*
4 gallons	*1/3 teaspoon*	*1/4 teaspoon*
8 gallons	*2/3 teaspoon*	*1/2 teaspoon*

**Bleach may contain 6 or 8.25% sodium hypochlorite.*

-- End EPA website quoted section --

Heat Disinfection

Boiling water will kill off any pathogens present, end of story. In fact, almost everything living in your water will be dead by the time it hits about 170 degrees Fahrenheit, but bringing it to a rolling boil is a great safety factor.

Boiling water can seem an imposing task without metal or glass cookware, but it doesn't have to be. The temperature of liquid water cannot exceed its boiling point, and neither can anything thin in direct contact with liquid water. This means paper, plastic that has a higher melting temperature than 212 degrees Fahrenheit (including disposable water bottles), or even bowl-shaped leaves are all viable containers to boil water over an open fire, so long as only portions of the vessel that are actually filled with water get into the high-heat areas.

Thicker containers can be used as well, though unfired ceramic and thick wood won't handle direct flames well. Here, a good supply of rocks and some sticks to be used as tongs solve the problem. Heat rocks in a fire, and scoop the hot rocks into your water container. Water takes more energy to heat than rocks, so expect to use a lot of rocks to heat a little water.

Water can also be pasteurized to render it safe. Pasteurization makes use of lower heats for longer times to cook the pathogens to death. According to research by Ciochetti and Metcalf, 150 degrees Fahrenheit for six minutes will kill all pathogens as well.

In warm climates, a dark container left in the sun can easily heat water hot enough to pasteurize, even if turbidity prevents the use of the next technique.

Ultraviolet Disinfection

Radiation is extremely effective at inactivating pathogens **in clear water**. The water must be colorless and free of suspended solids to allow radiation full access to the pathogens throughout the entire water column. Given that most of us don’t carry a radiation source, ultraviolet light from the sun is the radiation disinfectant of choice. Industrial ultraviolet lights are used to disinfect water in many municipal systems, but the sun can serve as another source.

Solar disinfection is widely recommended in third-world countries. The most common method is to fill clear two-liter soda bottles with clear water, toss them on the roof of a hut (or other area with a good long view of the sun) and retrieve them eight hours later. Industrial UV disinfection is much faster, but has a stronger ultraviolet source.

Natural containers, from clay bowls to shallow depressions in stones, can be used for solar disinfection as well. Don’t go deeper than 3” or so. If the water gets too deep, the ultraviolet waves will not be able to penetrate deep enough, and infected water could remain in the bottom.

A variety of ultraviolet water treatment options are available commercially for backpackers and survivalists, like the CamelBak All Clear for example. Ultraviolet “pens” are also available for insertion into non-proprietary bottles.

DISTILLATION

When most people think of distillation, water is often not the first substance to spring to mind. Distillation is the process of boiling a liquid to convert it to a gas, then condensing the gas back to a liquid, usually in an attempt to separate out a particular target substance.

When the goal of distillation is hard liquor, an initial wine or beer "mash" with relatively low alcohol content is boiled to extract the alcohol. This is possible because the boiling point of ethanol, 173° F, is about 40° F lower than that of water. So long as the mash is held at a temperature above the boiling point of alcohol, and below that of water, only the alcohol will boil off, giving almost pure alcohol gas to be condensed and then diluted down to a drinkable liquor.

Important Note: *Distillers of alcohol do not collect the first 5-15% of the alcohol vapors. These have too high a likelihood of being tainted with methanol, a toxic chemical that causes blindness or worse. The boiling point of methanol, 148° F, is even lower than that of ethanol, causing the methanol to flash off first. When attempting to purify water by distillation, this practice is a good one to follow. Any organic molecules with a lower boiling point than water (think benzene, methanol, etc.) will be super-concentrated in that first part of the condensate.*

When dealing with water high in heavy metals, minerals, or salts, distillation is the only real chance of producing drinkable water without expensive and complex industrial processes. It's also one of the most difficult purification methods to effect in the backcountry without metal, glass, or plastic. Active distillation requires vessels that can withstand heat for long periods, and passive distillation works best with a transparent sheet of plastic to let sunlight in, but collect water vapor.

Passive Distillation

Water vapor exists in the air, even without having to be boiled directly from a pot of water. Collecting that water vapor can be difficult, but there are cloth structures in deserts that can pull water from the air, enough to support small villages.

Of more practical use is the **solar still**, a solar-powered distillation method that represents minimal energy investment on the part of the user. Easy to construct with the right materials, it can even purify urine to a drinkable state, though that's not a great long-term strategy.

A simple solar still consists of some sort of vessel filled with suspect water, a condensation lid, and a catch vessel. The larger vessel can be as simple as a hole dug in moist dirt or near a body of water, or it can be a large pot, if you have one handy.

The lid can be leaves, pine boughs, plastic sheeting, or the proper pot lid itself. Use whatever is handy, can make a halfway decent seal on the large vessel, and can droop down to a small point in the middle. Ideally, a dark, semi-transparent lid will let sunlight in to heat the water and accelerate the process. If you're going for the hole-in-the-ground technique, a black trash bag material is great for the cover, held down by some large rocks on the perimeter, with a small rock placed in the middle to generate the drip-collection shape.

For a collector container, anything with a wide mouth is ideal, as the drips won't all come perfectly off the bottom of the middle of the sag point in the lid. A mug, bowl, half a coconut shell, or a wide-mouthed Nalgene bottle are all good options.

In the simplest example, dig a hole near the ocean, in a good sunny spot if you can. Then place your catch bowl inside, propped on some rocks up above the waterline so it doesn't float around. Stretch a trash bag over the top of the hole, weight it down with rocks around the perimeter, and set a small rock in the center to produce a sag point. Be mindful of the tide, don't let your nice little bowl of fresh water get swallowed up by the rising seawater.

I would highly recommend disinfecting any water collected via solar still. Moist holes in the ground tend to attract insects, and you may well have issues with bugs you can't see as well if you forgo disinfection.

Active Distillation

Any form of distillation takes time, but actively boiling water to convert it to steam accelerates the process. The cost of this acceleration is fuel to heat the water, and the energy you expend feeding that flame.

Coming up with a pot or other vessel in the wild that can withstand the prolonged heat of boiling water for hours can be difficult. In a civilized area, scrounging up a pot, pan, or some other vessel of glass, metal, or pottery should not be terribly challenging, but in the wilderness, you may need a bit more creativity. A thin plastic water bottle can take the boiling (the temperature of liquid water can't climb above its boiling point, which keeps the thin plastic cool enough not to melt, though it will sag), or a clay-lined vessel can be heated with many cycles of hot rocks. Neither of these would be an ideal option, which is why many bushcrafters and backwoods campers opt to use single-wall (not insulated!) stainless steel water bottles instead of plastic.

Assuming you manage to salvage something that can take the heat, you'll also need to figure a way of catching the steam. This can be as easy as finding a sheet of plastic (ideal) or could instead be a steam-catching condenser made up of banana leaves, fine pine boughs, palm fronds, or whatever else you can find and make work.

All that is needed here is to boil a lot of water to steam, catch the steam on something as condensation, then trickle it down into a catch pot. By allowing the water to boil a short while before you start catching the steam, you should get rid of many of the volatile organic compounds, and other nasty things with lower boiling points than the water itself. Also leave the last bit of distillate alone, as it can start to contain things with higher boiling points than water. The “head” and “tail”, as moonshiners call the first and last bit of distillate, are wise to avoid in any distilling situation, whether you’re dealing with alcohol or water.

Distillation will also leave behind heavy metals, salt, and other things you don’t want to be drinking. It’s just about the only option when it comes to purifying brackish water in the field, as you’re not likely to have any sort of fancy reverse-osmosis (EXPENSIVE) device on hand. Heavy metals and other industrial pollutants can sometimes be detected by an off-scent in the water, but many are more insidious like arsenic, and not very well detectable. This again underscores the importance of prior knowledge of likely contaminants in an area. Luckily most of those sneakier contaminants are largely localized to locations near mining, tanneries, and other heavy industry, but they absolutely can seep into the water from natural mineral deposits.

I would still hit the condensate with some sort of disinfectant, be it heat, UV, or chemical, just to be totally safe. The heat and distillation will leave behind or kill off any microorganisms that were in the original water, but it’s a long process, with open-topped containers sitting in high humidity for a long time. Plenty of time for contaminants to get into the final water supply if you’re not careful. Theoretically unnecessary, but not a bad idea if you have the luxury.

ADSORPTION

<u>**Activated**</u> charcoal can "soak up" many of the organic contaminants out there, as well as some heavy metals and other categories of nasty. I bold and underscore the word "activated" because not just any charcoal will do.

Charcoal is partially-burned wood (or some other carbon-rich material), and pretty easy to make in a rustic setting. It's a great fuel, and semi-adsorbent, meaning its surface is reactive and will readily bind up some nasty chemicals that can make you sick. Charcoal's ability to soak things up on a chemical level has been known for centuries, and used to help with poisonings by soaking up the poison in a person's stomach.

The **activation process** for charcoal is a nasty industrial thing, involving the introduction of other chemicals like chloride salts to bind with the carbon, further charring, and then an acid wash to remove those other chemicals. This leaves the now-activated charcoal an extremely porous material, very reactive to chemicals, and with an extraordinary surface area to weight ratio. Note that this isn't something you'll be doing yourself without a pretty sophisticated chemistry laboratory.

Industrial water treatment processes use a material called *granular activated carbon* (GAC) in their filter beds to help sop up chemicals and heavy metals. Designers of such systems opt for activated carbon over normal carbon (charcoal) because it is much, much more effective.

I tell you all this so you understand that charcoal is useful, but it's not nearly so potent as the industrial stuff. If you happen to get lost hunting with an activated charcoal scent control packet, crack that sucker open and use it for your water. For the rest of us, know that charcoal helps polish up water quality a bit, but is not really potent enough to be relied on as a stand-alone water purification method.

The most common “bushcraft” water filters you’ll see use a 2-liter soda bottle with the bottom cut off, packed with alternating layers of straw and filter media. The very bottom layer of filter media is typically crushed-up charcoal, then fine sand, medium sand, coarse sand, and gravel, all separated with straw or grasses.

These filters are decent rudimentary devices that certainly improve water quality, but you’ll still want to boil or otherwise disinfect the water afterwards. Large suspended solids will be strained out, as well as large microorganisms if you have fine enough sand, and the charcoal will react out **some** of any other chemicals or microorganisms present, but not all of them.

For emergency-preparedness, stocking some activated carbon and learning to use it properly could be a great idea. It’s not terribly expensive, and can be very useful for first aid and water treatment. If it’s good enough for commercial water treatment, it’s good enough for us. Unlike with the bleach-dosing methods, it’s pretty hard to actually hurt yourself using activated carbon in a reasonable way, but still try to find a good reference from someone with more expertise before attempting.

RECOMMENDATIONS AND REMINDERS

Assume you'll need at least two methods to render almost any water source relatively safe. In the vast majority of backcountry and wilderness areas in the United States, the biggest issues you'll encounter are turbidity and microorganisms. Filter first to pull out the suspended solids, then disinfect.

If you're dealing with brackish water, or known heavy metals, then distillation is your friend. Whether you opt for the long passive process of a solar still, or speed things up by heating water to boiling, distillation is a slow and tedious process, so it pays to continue seeking a better source of water.

Bear in mind that filtration and disinfection aren't going to fix everything possibly wrong with water. It's best to know what contaminants are common in your area, and develop some skill in their removal. Failing that, avoid anything with a harsh chemical odor, period.

Charcoal can help a bit, but it won't make something that smells bad enough for you to naturally want to avoid it into safe drinking water. Several applications of the right kind of activated carbon could potentially do it, but I would trust it without some really fancy water-quality testing to be sure.

Remember that as much of a pain as purifying water is, the consequences of not taking the time to do so can be much more painful, if not deadly.

COMMON WATERBORNE ILLNESSES

If you suspect you may have come into contact with bad water, it’s best to expedite your exit from the backcountry. You might be fine and cut a trip short, but the alternative is being very not fine, far from help.

For those curious, I’ve assembled a list of the most common waterborne illnesses in the US, and their typical symptoms. **This does not constitute medical advice, and is for information purposes only.** Always seek the advice and assistance of a qualified medical professional.

According to Lifewater, the seven most common waterborne diseases are Typhoid Fever, Cholera, Giardia, Dysentery, E. coli, Hepatitis A, and Salmonella. The following short descriptions and symptoms are summarized from the Centers for Disease Control website.

Note that dehydration and diarrhea are the most common symptoms for all of these illnesses, and trying to weather those symptoms in a remote setting can be uncomfortable, or even deadly.

Typhoid Fever

Life-threatening disease caused by *Salmonella* serotype Typhi, can be vaccinated against. Typically not found in the United States, but can be encountered while traveling abroad.

- High Fever
- Generalized Weakness, Fatigue

- Stomach Pain
- Diarrhea or Constipation
- Headache

Cholera

Diarrheal illness caused by exposure to the *Vibrio cholerae* bacterium. Most often mild or asymptomatic, cholera can be life-threatening, especially when contracted in a remote setting.

- Profuse Diarrhea
- Dehydration
- Shock and Seizures in Extreme Cases

Giardia

Intestinal parasites, infection with which is called giardiasis.

- Diarrhea
- Gas
- Greasy, often floating stool
- Cramping
- Dehydration

Dysentery

Also frequently called “infectious diarrhea”, dysentery can be caused by bacteria or amoeba infections.

- Diarrhea (often bloody)
- Abdominal Pain and Cramping
- Nausea and Vomiting
- Gas

Escherichia coli (E. Coli)

Illness caused by toxins produced by certain *Escherichia coli* bacteria. Presentation varies erson to person and based on strain of bacteria.

- Severe Cramps
- Diarrhea (often bloody)
- Vomiting
- Low-grade fever

Hepatitis A

Viral infection of the liver. Typically contracted by ingestion of very small amounts of virus in water contaminated with blood or feces of an existing carrier. Highly contagious, vaccine-preventable.

- Fatigue
- Nausea
- Stomach Pain
- Jaundice (yellow cast to the whites of eyes and skin)

Salmonella

Another bacterial infection, this one is usually caused by food poisoning in the US, though it can be waterborne as well.

- Diarrhea
- Fever
- Stomach Cramps

CONCLUSION

Thank you again for downloading this book!

Now that you've read more about what dangers found water can have and how to treat them, I hope you feel more comfortable preparing for and dealing with emergencies at home, while camping, or in a survival situation, and have a greater understanding of why certain fire lays are better suited to particular situations.

Now it's on to you to get out and practice. It's one thing to read about the techniques in a book, but skills like these require more finesse and experience than can be gained by reading thousands of books. The only way to really learn to make a fire with a bow drill is to practice, so get out there and try it, before your life depends on it!

Finally, if you enjoyed this book, please take a moment to leave a review for this book on Amazon. It would really help me spread this book to a wider audience!

Click here to leave a review for this book on Amazon!

Want more? Head over to my website,
https://bengordonoutdoors.com, for loads of articles, videos, and interactive maps on all sorts of outdoor topics!

Thank you, get out and practice, and good luck!

EXCERPT FROM MY FIRE BOOK: PRIMITIVE FIRE-STARTING METHODS

Tinder is much more important in primitive methods than in modern methods. Many primitive methods require more steps to transition from the initial ignition to a self-sustaining fire, forcing more reliance on the initial fuel. While some ignition source / tinder combinations will deliver flames like a butane lighter, many will only produce small, glowing coals which need to be supported and sustained until they can be worked into flames.

Types of Tinder

In North American boreal forests, small bits of bark off paper birch trees can be stripped away without damaging them, and fatwood can be collected from rotting downed evergreen trees. Fatwood is evergreen wood super-impregnated with resinous sap. It is often found at the shoulder of a tree where limbs meet the trunk, or in the center of rotting stumps. Both birch bark and fat wood are very flammable, and if powdered thin by peeling or rubbing with a knife blade, can ignite directly from repeated showers of sparks.

Other tinder sources generate small glowing coals, which must be transferred to a “bird’s nest” of dry grass, bark, or wood shavings, and blown into flame. Some natural examples in a boreal forest are dry cattail fluff and amadou, the fluffy inner skin of the horseshoe fungus or “tinder fungus” (*fomes fomentarius*). The coal generated by friction fire methods will behave the same way. These coals are very fragile and must be handled with extreme care to avoid putting them out, especially when hard-won through friction methods.

With a little forethought, char cloth and other similar materials can be prepared. Char cloth is created by heating cotton or other types of natural fiber in the absence of oxygen, burning off some of the Volatile Organic Compounds (VOCs), which leaves behind mostly purified carbon. Char cloth, like charcoal, lights easier than the original material, and burns hot. An easy way to make char cloth is by loading a metal tin with cloth, poking a hole in the lid, and setting the tin on the edge of a fire. When the VOCs start to leave the cloth, a small candle-like fire will ignite above the hole, and burn until the VOCs are gone, at which point the tin can be retrieved and allowed to cool. It smolders as a coal when first lit but can be easily blown into flame without need of a nest. Other materials, such as amadou or cattail fluff, can be treated similarly to create other charred tinders.

Fire by Friction

Friction fires demand the most planning of any fire-starting method, absolutely dry materials, and the right combination of hardness and resin content of the plough/drill and hearth board. The coals generated are very fragile and need to be transferred cautiously to a bird’s nest, blown into flame, and transferred into a ready-built fire lay. Creating easily combustible sawdust that can be ignited by the low-grade heat of manual friction relies heavily on the dryness of the base materials. Some wetness can be overcome with exceptional vigor in using the techniques listed in this chapter, but not much. The goal is to rub sticks together, generating heat and sawdust, until the sawdust starts to smolder and condenses down on itself to form a tight coal. The hardness of the wood pieces and resin content influence the quality of sawdust for coal formation, and the right combination of wood species can take some experimentation to find. Various sources making conflicting claims on which should be the harder piece of wood.

Two pieces of wood are required for a fire plough: the plough and the hearth board. The plough is a hard, dry stick, about thumb-thick and the length of a forearm, held with one or both hands. The hearth board sits on the ground and can be held in place by a foot, or the hands of a partner. The plough is rubbed back and forth, carving a trench in the hearth board, creating sawdust and heat from the friction. The trench can be started by carving out a channel, using a blade or rock, but this isn't strictly necessary. Ideally, the bottom of the hearth board is flat, to prevent wobbling around, but a rounded log can be chocked in place with rocks, other sticks, or a channel dug into the ground. Another forearm length log, this one about twice wrist thickness, with the top and bottom third split off is a great candidate for this board. Again, dryness of the materials is essential. Given enough time, the correct amount of pressure, and a bit of skill, it's possible to coax a coal out of the sawdust, transfer it to a bird's nest, and blow it into flames.

The other major class of fire by friction is the drills group, which are all variations on the hand drill, the simplest form. A hand drill set consists of a spindle and hearth board, this hearth board can be much smaller than the one used in a fire plough. The most important dimension for a hearth board is thickness, as a notch needs to be cut or carved into the edge of the board to funnel the dust into a coal. Instead of rubbing a stick back and forth, the drill uses friction from the spindle rotating in a hole, much like a power drill, to produce the coal. The hand drill spindle should be a hard, dry, very straight stick, about the length of an arm. The bottom of the spindle should be about the diameter of a penny, slightly thinner at the top. The spindle needs a rounded point on it. The hearth board, should be half an inch thick and needs a hole started with the tip of a knife, centered about the thickness of the spindle away from the edge.

The tip of the spindle is then set into the beginning of the hole, with both hands on either side of the spindle, in a prayer pose at the top end. With a firm, downward pressure, rotate the spindle back and forth between your hands, allowing them to progress down its length to a few inches above the hearth board. Reset your hands at the top, and repeat the action, over and over, until a good hole is formed. At this point, darkened sawdust should be visible rimming the hole on all sides. To collect and concentrate the rest of the dust, a notch needs to be cut into the hearth board. Starting at the edge of the board, make two cuts towards just shy of the center of the hole, spaced about half an inch apart on the board edge side. Set the resulting v-shaped notch over something to catch the coal, like a dry chip of bark or thin split of wood, and ensure the bird's nest and fire lay are ready. The spindle must then be set back in the hole, and spun vigorously, but with endurance in mind, as even with good materials and the right shapes, this process will take several minutes. Eventually good dark sawdust should start to collect into a coal, and a thin wisp of smoke will trail out after several more minutes of work. The first wisps will not indicate a robust coal; the drilling must be continued for several more minutes to consolidate the coal and ensure success.

A bow drill uses the same idea of a spinning stick, but the higher technology allows for inferior quality woods to be used with success. A bow drill set consists of four pieces: a hearth board; a shorter, thicker spindle; a top block; and a small bow. The hearth board is the same as that used in the hand drill, and the spindle is similar, but only about forearm length and thicker, at about the diameter of a nickel. The top block can be anything low friction, from a smooth piece of wood or rock, to a knife handle with a hole in it. This is held in the non-dominant hand, braced against the knee of the foot holding down the hearth board, and is used to provide and control the downward pressure on the spindle. The "bow" is a springy stick about arm length or shorter, with some sort of robust cordage to serve as a string.

The spindle is twisted into the string of the bow, taking care to ensure it does not end up between the string and the bow stick, but rather on the outside of the string to avoid pinching and throwing the spindle. Once the spindle is looped in and seated into both the spindle and top block, the bow is moved forward and back in a sawing motion, taking care to balance the spinning and downward pressure. The usual technique to manage all the pieces of a bow drill is to (from a crouch with the knee of your dominant hand side on the ground behind you) hold the hearth board down with your foot on your non-dominant-hand side, with the top block gripped in your non-dominant-hand, pressing down and braced against the knee. The dominant-hand side knee is set on the ground behind, and the dominant hand holds the bow.

Once the hearth board hole and notch are primed and ready, the user saws away vigorously on the bow, taking care to balance the downward pressure with the non-dominant hand. With proper materials and technique, a good coal can be generated in under a minute, but lower quality material or imperfect technique may require several minutes of work before a coal is generated.

Fire by Spark

With the right tinder and some source of sparks, a fire can be made with much less energy expenditure than by friction. Spark sources in the modern day can be a battery and steel wool or a foil gun wrapper, a ferrocerium rod, or striking various metals against each other, but in the back country, sparks have to come from less obvious sources. Flint and steel were the tools of choice for European explorers, but flint is not always readily available. Fortunately, any object harder than steel can be used to create sparks by striking it against steel. The sparks are just tiny flakes of steel, shaved off by the impact, and superheated by friction and rapid oxidation as they fly. Chert, obsidian, quartz, flint, and even glass are some of the most common, but for the non-geologist, trial and error works fantastically to find a hard, spark-producing rock.

On the topic of spark-producing steels, many modern stainless steels are far more difficult, if not impossible, to create sparks from, and many knives and other outdoor supplies are now made from stainless steel. When stuck without good carbon steel to spark, trial and error of smashing rocks against each other can still sometimes produce serendipitous sparks, perhaps from iron-bearing ores. The best spark-catching tinders for starting fire in this way are char cloth, and dryer lint from a good load of new cotton towels. In the absence of those tinders, finely shaven or powdered birch bark or tinder fungus will do.

When using a purpose-built steel striker from a flint and steel kit, the tinder is set on top of the flint fragment, which is held with a very sharp, chipped edge pointed outward toward the other hand. The second hand, holding the steel, strikes downward along the edge of the stone, tossing shaved-off sparks onto the tinder, hopefully starting a smolder. The spine of a knife can be carefully used in place of the steel striker, but when using more improvised spark sources, tinder placement will need to be carefully considered to avoid injury while maximizing likelihood of catching the spark.

Fire by Refraction

The sun provides plenty of energy to start a fire as well, you need only focus it. Any clear object that’s convex (bowed out) on both surfaces can be used to focus the sun’s light and heat from a large area into a smaller area, raising the temperature. Some children use magnifying glasses to focus the sun and burn ants, but a better use of this power is starting fires.

Fire by refraction was my favorite show-off method as a kid at camp, especially because the counselors usually doubted it would work. With a large enough lens, even low-quality tinder can take light, but with most small magnifying glasses or other lenses, very dry paper works best. To practice, use dry paper and a very large magnifying glass.

Pick a sunny day (it can work with clouds, but is much easier without), a large glass, and some balled-up newspaper. Head to an area with open sky and put the sun behind your back. Set the newspaper on the ground and hold it down so it doesn't blow away and bring the magnifying glass up as if looking through it at the paper.

The glass needs to be lined up with the sun shining straight on it to work most effectively, imagine the surface of the glass is the mouth of a long tube you're trying to shoot the sun's light straight down onto the paper, and you'll be pretty close. Then start moving the glass towards and away from the paper, watching the circle of light expand and contract on the paper. Be careful, it can burn you when focused correctly, and the very bright light can hurt your eyes if you stare at it too long.

The trick is to blow gently on the newspaper. Try to keep the circle of light as small as possible on the paper. If the paper doesn't immediately burst into flames, try tilting the glass a bit in each direction, and moving refocusing it on the page. Sometimes it's easiest to see that the lens isn't tilted properly by purposely un-focusing the circle of light until it's about dime-sized and looking to see if it's perfectly round. Any tilt to the alignment will cause the circle to get squished into an oval, and that small misalignment will make lighting the paper much harder.

When the paper chars away in one spot, chase an edge of the hole with the light, and keep gently blowing on it. The heat is there, you just need enough oxygen. It can take some effort to get it the first few times, but the satisfaction is quite worth it.

The very large magnifying glass just makes it easier, in the right conditions, I've used lenses about the size of a dime. Other objects can be used as well, including water bottles, ice chunks, or glasses of far-sighted people (most people with glasses are near-sighted). Anything clear and convex will work.

* * *

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