ROPES • KNOTS, BENDS, AND HITCHES • HELMETS • HARNESSES • RUNNERS • CARABINERS • KNIFE • KEEPING THE SAFETY NET STRONG

CHAPTER 9
BASIC SAFETY SYSTEM

The climbing safety system protects you when the difficulty of a pitch or an unexpected occurrence—a slip or a collapsing snow bridge—causes you to fall.

The safety system is more than just a rope. It also includes the harness that attaches you to the rope, the knots and carabiners that join the various parts of the climbing system, and the loops of webbing (known as runners) used to connect the rope to rock, snow, or ice. This chapter provides an understanding of the mechanical components of the safety system and how to use them effectively and safely. Avoid using any critical climbing equipment if you are unfamiliar with its history. Secondhand equipment, whether found or passed along without an account of its use, increases the possibility of a weak link in the chain protecting the lives of you and your climbing partners.

ROPES

Nylon climbing ropes are lightweight and very strong, capable of bearing a load of more than two tons. They also have the remarkable quality of elasticity, which is the critical component in the rope's ability to protect a climber in a fall. Rather than bringing a falling climber to an abrupt, jolting stop, nylon ropes stretch and dynamically dissipate much of the energy generated by the fall, thereby reducing the forces associated with the fall.

Early nylon ropes were of "laid" or "twisted" construction. They were composed of many tiny nylon filaments bunched into three or four major strands that were then twisted together to form the rope. Gradually, twisted nylon ropes were replaced by kernmantle ropes designed specifically for climbing. Today's kernmantle ropes (fig. 9-1) are composed of a core of braided or parallel nylon filaments encased in a smooth, woven sheath of nylon. Kernmantle rope maintains the advantages of nylon but minimizes the problems associated with ropes constructed by twisting: stiffness, friction, and excessive elasticity. Kernmantle ropes are now the only climbing ropes approved by the International Climbing and Mountaineering Federation (Union Internationale des Associations d'Alpinisme, UIAA), the internationally recognized authority in setting standards for climbing equipment, and the European Committee on Standardization (Comité Européen de Normalisation, CEN, listed as "CE" on equipment labels), the European group responsible for creating and maintaining standards for all equipment, including climbing gear (fig. 9-2).

VARIETIES OF CLIMBING ROPE

Climbing ropes are available in a great variety of diameters, lengths, and characteristics. Any rope used for climbing should have the manufacturer's label, a UIAA or CEN rating, and specifications such as length, diameter, elongation or impact force, and fall rating. Rope measurements universally use the metric system; in this book, imperial units of measurement (inches, feet, and so on) are occasionally given in parentheses as well.

Dynamic. Kernmantle ropes designed for climbing are termed "dynamic" ropes. Dynamic ropes achieve low impact forces by stretching under the force of a fall. One of the most important considerations when looking at rope specifications is the impact force—generally, lower is better. Using a rope with a lower impact force means that a climber's fall will be stopped less abruptly (a "softer catch") and less force will be imparted onto the fallen climber, the belayer, and the anchor system.

TABLE 9-1. SOME TYPICAL ROPES AND THEIR COMMON USES

DIAMETER	TYPE	COMMON USE
10.1–11 mm	Dynamic	Most durable single rope for rock and ice climbing (the workhorse)
9.5–10 mm	Dynamic	Moderate-weight single rope for rock and ice climbing (versatile)
8.9–9.4 mm	Dynamic	Lightweight single rope for rock and ice climbing and glacier travel
8–9 mm	Dynamic	Part of a double-rope system for rock and ice climbing or a lightweight single rope for simple glacier travel
7–8 mm	Dynamic	Part of a twin-rope system for rock and ice climbing
9–13 mm	Static	Fixed lines on expedition-style climbs, caving, or rescue and haul lines on big walls (not for lead climbing)

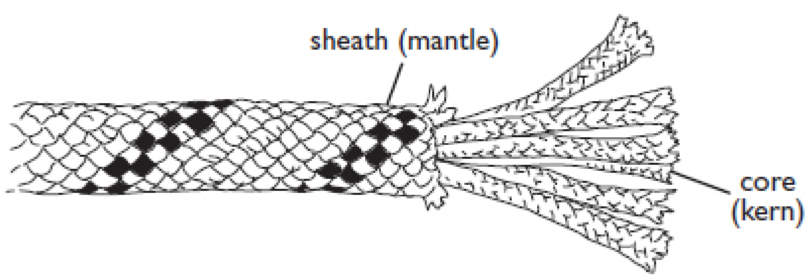

Fig. 9-1. Construction of a kernmantle rope.

UIAA

Fig. 9-2. The logos of the two organizations that approve kernmantle ropes.

Dynamic ropes come in a variety of diameters that are acceptable for technical climbing. Table 9-1 illustrates some typical ropes and their common uses. Smaller-diameter dynamic ropes (down to about 7 millimeters) are typically used in pairs as part of either a twin-or double-rope system (see Chapter 14, Leading on Rock). These small-diameter rope systems rely on the elastic properties of both ropes to protect the climber and must be used as a pair. The current trend in rope manufacturing—and, therefore, in rope use—is toward thinner and lighter ropes, but it is important to keep in mind that every rope is rated for certain intended uses, as indicated on the rope's label.

Dynamic ropes also come in a variety of lengths. Useful lengths range from 30 meters to 70 meters. Although 60 meters (200 feet) is the most common length for all-around recreational climbing, a climber might want to choose a rope that is either shorter or longer, for a variety of reasons. Rope weight, the nature and length of the route, and the ability to rappel safely are some things to consider when selecting a rope's length.

Static. In contrast to dynamic ropes, static ropes, nylon slings, and cord stretch very little, and a fall of even a few feet on nondynamic materials such as these can generate impact forces severe enough to cause failure of the anchor system or severe injury to the climber.

Climbers use no-stretch or very low-stretch ropes for purposes other than protecting the lead climber, including cave exploring or rescue work, as fixed line on expedition-style climbs, or sometimes as the haul line, jug line, and rappel line during aid climbing. Although static ropes often are sold at climbing stores, these ropes should never be used for lead climbing, which requires the impact-absorbing qualities of a dynamic rope.

Colors of Ropes

Ropes are manufactured with different patterns and colors woven into the sheath. Some ropes have a few inches of contrasting color at the midpoint; bicolor ropes have a change in color or pattern at the midpoint to make it easy to find the middle of the rope and differentiate the ends. Others have distinctively colored ends so that it is easier for climbers to visually determine that the end of the rope is being reached while they are belaying or rappelling. If a climb calls for two ropes, it is useful to use different colors to assist climbers in distinguishing between the ropes. The UIAA warns against marking a rope with any substance that has not been specifically approved by the rope manufacturer.

Water-Repellent Ropes

Wet ropes, in addition to being unpleasant to handle and heavy to carry, can freeze and become very difficult to manage. Equally important, studies show that wet ropes hold fewer falls and have about 30 percent less strength than the same ropes when they are dry.

Rope manufacturers treat some of their ropes with either a silicone-based coating or a synthetic fluorine-containing resin coating (such as Teflon) to make them more water-repellent and therefore stronger in wet conditions. The "dry rope" treatment improves the abrasion resistance of the rope and also reduces friction of the rope as it runs through carabiners. Dry ropes usually cost about 15 percent more than untreated ropes.

PERFORMANCE TESTS

The UIAA and CEN test equipment to determine which gear meets their standards. Because climbing is a sport in which equipment failure can be fatal, it is wise to purchase equipment that has earned UIAA and/or CEN approval.

In its rope tests, the UIAA checks the strength of the single ropes used in most climbing—which generally measure between 8.9 and 11 millimeters in diameter—and also the thinner ropes used in double-rope climbing. To receive UIAA approval, a rope must survive a required minimum number of falls. The tests measure the impact force of the rope, which determines the stress of the fall on the climber's body and on the pieces of protection.

The UIAA also applies static tension tests to determine how much the ropes elongate under load. Approved ropes do not stretch by more than a specified percentage.

ROPE CARE

A rope protects your life and must be treated with care.

Preventing Damage to the Rope

Stepping on a rope can grind sharp particles into and through the sheath. Over time, the particles act like tiny knives that slice the rope's nylon filaments. Climbers wearing crampons must be doubly careful about keeping off the rope, because a misstep could damage the rope. Crampons may damage the core of a rope without leaving any visible gash on the sheath.

Protect the rope from contact with corrosive chemicals (especially acids) that might damage the rope. For example, parking lot surfaces or a car trunk or basement may harbor substances that could damage a rope.

Washing and Drying

Follow the manufacturer's recommendations for care. Most ropes should be washed frequently with tepid water and mild soap, although some manufacturers recommend against using petroleum-based or other detergents on water-repellent ropes. The rope's water-repellent finish can also be renewed with aftermarket products made for that purpose. A rope can be washed by hand in a bathtub or in a front-loading washing machine (ropes can get caught under the agitator in a top-loading machine). Rinse the rope several times in clean water and then hang it to dry, out of direct sunlight.

THE LIFE OF A ROPE

Following are some general guidelines to help climbers decide when to retire their ropes:

- A rope used daily should be retired within a year.
- A rope used on most weekends should give about two years of service.
- An occasionally used rope should be retired after about four years (nylon deteriorates over time).

Storing

Before storing any rope, be sure it is completely dry. Remove all knots, coil the rope loosely (see "Coiling the Rope," below), and store it in a cool, dry area away from sunlight, heat, petroleum products, and corrosive chemicals such as acids.

Retiring a Rope

Examine a rope's sheath to get the best picture of the rope's overall condition. Inspect ropes frequently, particularly after a fall, to ensure that the sheath is clean, that there are no abraded or soft spots in the rope, and that the ends are properly fused and not fraying or unraveling. If a crampon wound, excessive abrasion, rockfall, or a sharp edge leaves the sheath looking tattered, the rope's integrity should be seriously questioned. If the core of the rope is visible, it is time to retire the rope.

It is harder to decide when to retire the rope if it does not contain any obvious soft spots or scars in the sheath. The rope's actual condition depends on many factors, including frequency of use, the care it has received, the number of falls it has endured, and how old it is.

After a severe fall, it may be wise to replace a rope, particularly if any segment of the rope feels mushy or flat. In deciding whether to retire the rope, consider the rope's history and other factors affecting its condition. The guidelines for rope replacement (see "The Life of a Rope" sidebar) assume that the rope is kept properly cleaned and stored.

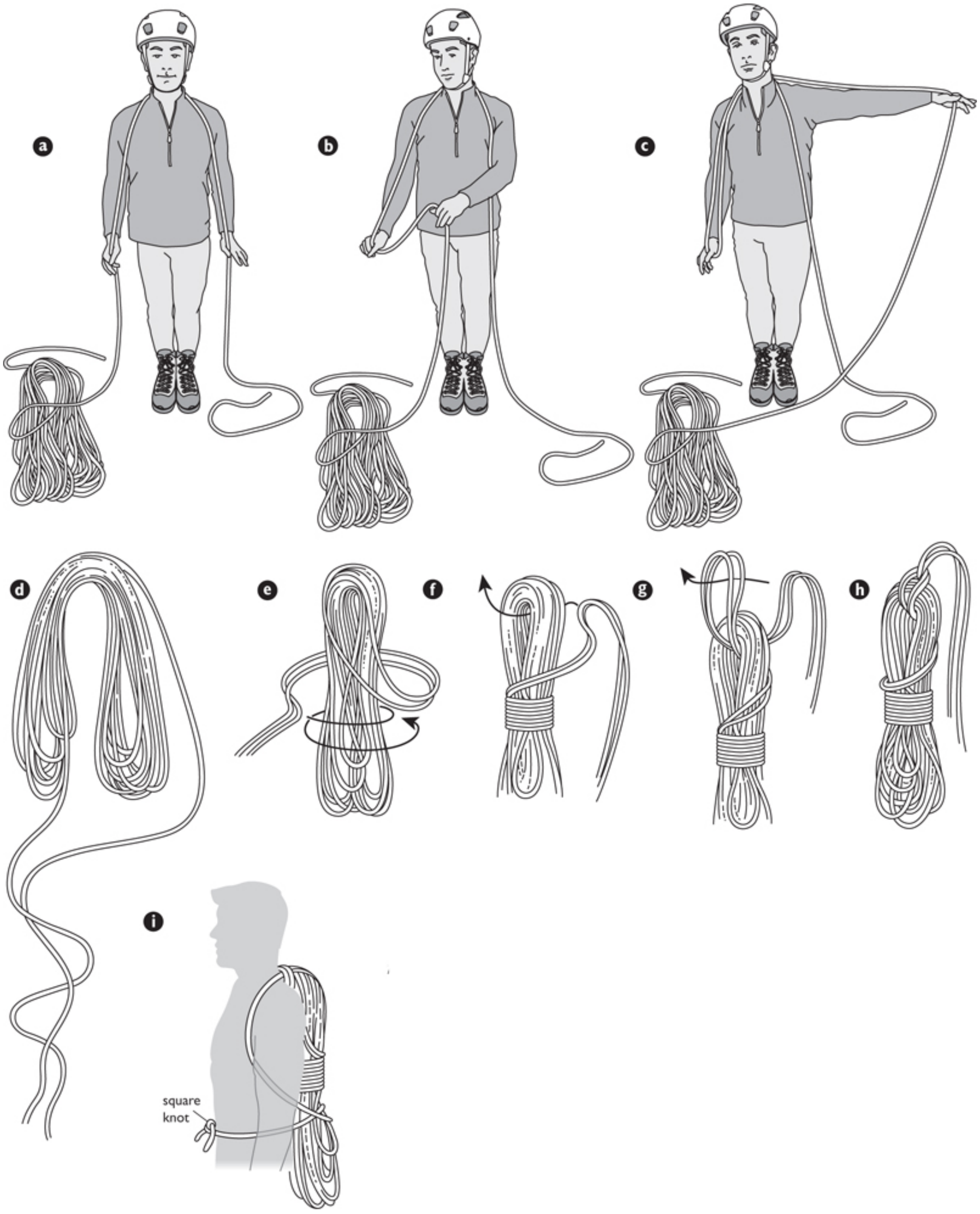

Fig. 9-3. Butterfly coil for a rope carry: a, holding one end of the rope with your left hand and leaving an ample tail, with your right hand pull the rope up and overhead to drape against the back of your neck; b, with your right hand remaining in place to hold the end of the coil, bring your left hand to your right to draw a bight from the free end of the rope, and drape this up and overhead to the left; c, repeat this step, alternating hands, until most of the rope is coiled, leaving an equally long final tail; d, for the carry, lift the coils off your shoulders; e, wrap the tails around the middle of the coils several times; f, starting from the last wrap, make a bight using both strands of loose rope and feed this bight through the upper loop of the coil; g, bring both ends of

the tail all the way through this bight; h, cinch; i, put a rope end over each shoulder, cross these around behind your back, over the coiled rope, then back again forward around your waist to secure the load with a square knot.

COILING THE ROPE

For carrying or storing, the rope is normally coiled, most commonly in the butterfly coil. Once it is coiled, the rope can be tied snugly to your body if you are not wearing a pack. Below are steps to create a single butterfly coil using your arms as a measure and your neck and shoulders to rest the coils. The rope can also be coiled starting from the middle, coiling two strands at a time to form a double coil. While somewhat faster, this double coil is much more likely to tangle than the single butterfly coil, and is therefore not recommended.

Butterfly coil. Fast to create and easy to undo, a single butterfly coil does not kink the rope. To coil the rope, hold one end of the rope with your left hand, leaving an ample tail (two "wingspans" is a good guideline), and slide your right hand out along the rope, then lift the rope length created up and over your head and drape it against the back of your neck (fig. 9-3a). Next, bring your left hand to your right hand (fig. 9-3b) and use your free left thumb to pull a bight of the free end of the rope up and over your head while your right hand remains in place and holds the end of the coil (fig. 9-3c). Hold this coil in place while using your right hand this time to pull a new bight of rope to drape up and over your head. Continue alternating these moves from left to right, making and placing new coils until you reach the end of the rope, leaving a tail equal in length to the other tail. Shorten the last coil if necessary to adjust the tail. This will result in multiple coils in the shape of a horseshoe (fig. 9-3d).

To secure the horseshoe of coils, gather the two loose tail ends together and wrap them tightly and neatly around the middle of the coil several times (fig. 9-3e), avoiding twists. Bring a bight of the two loose ends through the loop at the top of the coil that is created by wrapping the coil's middle (fig. 9-3f), pulling enough of the tails through to form a good-sized loop. Then bring the rest of the loose tail ends through this good-sized loop (fig. 9-3g), drawing the loose ends all the way through (fig. 9-3h). To tie the butterfly coil to your body, place the coil against your back and draw one of the loose ends over each shoulder and around your back, crossing them over the coil and bringing them around your waist; tie them together in front (fig. 9-3i).

Flaking out the rope. It is important to uncoil the rope carefully before you use it, to minimize the chance of coils balling up into a tangle. Do not just drop the coils and start pulling on one end, which will create a tangled mess. Untie the cinch knot and then uncoil the rope, one loop at a time, into a pile, a procedure known as "flaking out the rope." Always flake out the rope before each belay to avoid twisting, knots, and tangles.

Rope bags or tarps. Alternatives to coiling the rope include using rope bags or tarps. Either can be used to protect a rope during transport. The unfolded rope bag or tarp also protects a rope from sand and grit on the ground. The bags and tarps add weight and cost, but for certain situations, such as cragging, they are worth it.

KNOTS, BENDS, AND HITCHES

Knots allow you to use the rope for many special purposes. Knots let you tie in to the rope, anchor to the mountain, tie two ropes together for long rappels, use slings to climb the rope itself, and much more. In common usage, the word "knot" is often used generically to refer to either a knot, a bend, or a hitch. But, properly speaking, they are different from each other. A *knot* refers to material tied on itself; a *bend* refers to a joining of material ends; a *hitch* refers to material tied around a solid object. In this book, the word "knot" is often used in its all-inclusive sense.

Climbers rely most heavily on a dozen or so basic knots, bends, and hitches. Practice these knots until tying them is second nature. Online sources such as the Animated Knots website and app (see Resources for this chapter) can be valuable resources for learning to tie these knots. Know that all knots weaken the rope, some more than others. In drop tests and pull tests, when a rope does break, it typically breaks at the knot. Table 9-2 shows the typical strength reduction of some knots. Some knots may be preferred over others because of their strength. Others may be chosen because they are easier to tie or are less likely to come apart in use.

Some terms and techniques are common to all knot tying, regardless of which knot is used. The end of the rope that is not being actively used is called the *standing end*; the other end is called the *loose end.* A 180-degree bend in the rope is called a *bight*; a *loop* is formed when the rope is curled around in 360 degrees so that both ends of the loop join or overlap. A *double knot* is a knot tied in a pair of ropes or in a doubled portion of one rope.

Regardless of what type of knot you tie, tie it neatly, keeping the separate strands of the knot parallel and free of twists. Tightly cinch every knot by pulling on each loose strand, and tie off loose ends with an overhand knot (see below). Always tie knots in perfect form so it becomes easy to recognize a properly tied knot. In the words of Colorado mountain guide and climber Michael Covington, "A good knot is a pretty knot." Develop the habit of routinely inspecting your own knots and those of your climbing partners, particularly before beginning a pitch or a rappel. As a general rule, keep knots away from points of greatest stress, sharp edges and corners, friction, and abrasion.

TABLE 9-2. REDUCTION IN BREAKING STRENGTH OF A SINGLE KERNMANTLE ROPE AT THE KNOT (relative to an unknotted kernmantle rope)

KNOT	REDUCTION IN BREAKING STRENGTH	KNOT	REDUCTION IN BREAKING STRENGTH
Bowline	26–45 %	Figure eight on a bight	23–34 %
Butterfly knot	28–39 %	Girth hitch	25–40 %
Clove hitch	25–40 %	Overhand loop	32–42 %
Double fisherman's bend	20–35 %	Square knot	53–57 %
Figure-eight bend	25–30 %	Water knot (ring bend)	30–40 %

Source: Clyde Soles, *The Outdoor Knots Book* (see Resources).

BASIC KNOTS

Basic knots are used for tying in to harnesses, for tying ropes together for rappel, for tying slings, and for anchoring and rescue procedures.

Overhand Knot

To tie an overhand knot, pass the loose end of the rope through a bight of rope (fig. 9-4a). The overhand knot is frequently used to secure loose rope ends after another knot has been tied. For instance, the overhand knot can be used to secure rope ends after tying a square knot (fig. 9-4b) or a rewoven figure eight (fig. 9-4c).

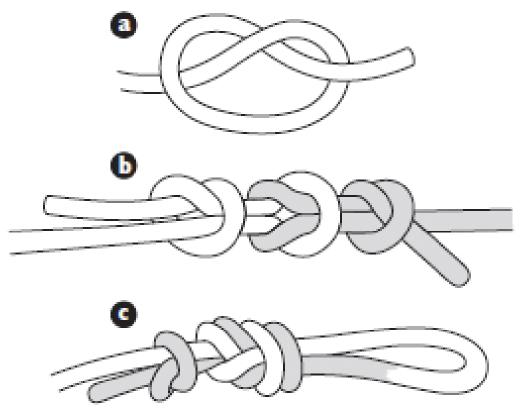

Fig. 9-4. Overhand knot: a, tying an overhand knot; b, overhand knots backing up both sides of a square knot; c, overhand knot backing up a rewoven figure eight.

Flat Overhand Bend (a.k.a. Offset Overhand Bend)

The flat overhand bend is tied using the loose ends of two ropes to set up a double-rope rappel (fig. 9-5a). Be sure to leave at least 12 to 18 inches of tail (fig. 9-5b) to prevent the knot from working itself loose. Compared with the double fisherman's bend (see below), this knot has a lower profile, and thus is less likely to be caught on edges, stuck in cracks, and tangled on trees when the rappel rope is retrieved.

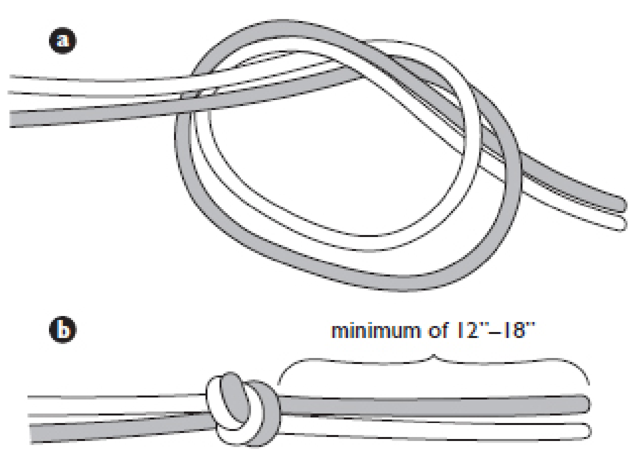

Fig. 9-5. Flat overhand bend: a, tie an overhand knot in two strands of rope; b, pull all four strands tight.

Overhand Loop

The basic overhand loop is tied using a bight in the rope rather than a loose end (fig. 9-6). The overhand loop is often used for creating leg loops in accessory cord as part of the Texas prusik system (described in Chapter 18, Glacier Travel and Crevasse Rescue) or to make a loop in a doubled rope or a length of webbing.

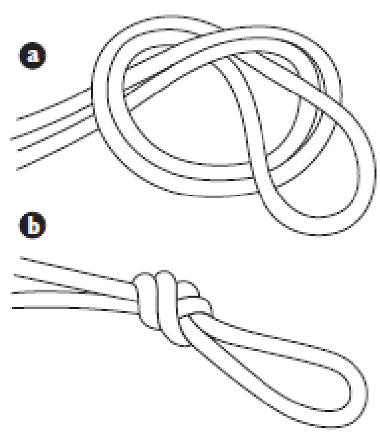

Fig. 9-6. Overhand loop: a, tie an overhand knot in a bight of rope or cord; b, dress and pull all strands tight.

Water Knot (Ring Bend)

The water knot, also known as the ring bend, is frequently used to tie the two ends of a length of tubular webbing (fig. 9-7a, b, and c) into a runner (see "Runners" later in this chapter). A water knot can work loose over time, so it is important to cinch the knot by pulling each of the four strands tight and to make the tails of the knot at least 2 to 3 inches (5 to 7.5 centimeters) long (fig. 9-7d). Check water knots often and retie any that have worked loose or that have short tails.

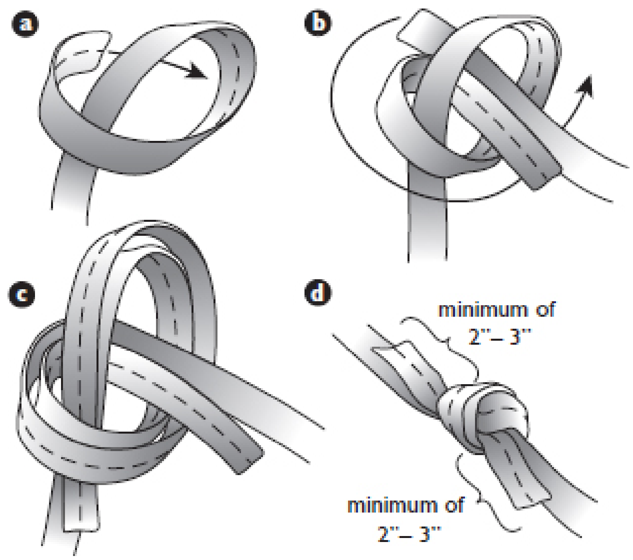

Fig. 9-7. Water knot (ring bend): a, draw a loose end through a bight of webbing; b, bring other loose end through the bight, around the first end, and under itself; c, draw ends well through knot so 2-to 3-inch tails extend; d, pull all four strands tight.

Square Knot

The square knot (fig. 9-8) can be used to join two ends of a rope together—for example, to secure the ends of the butterfly coil when it is carried on a climber's back (see Figure 9-3i).

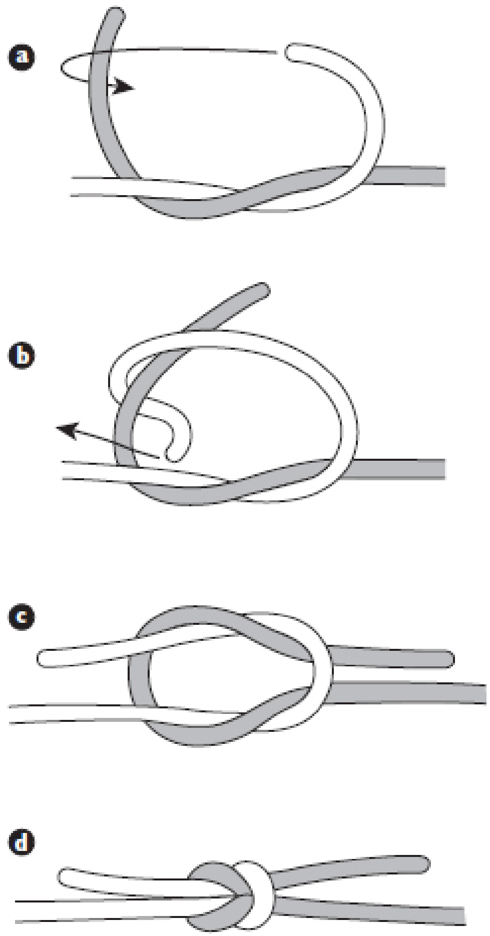

Fig. 9-8. Square knot: a, cross two loose ends over each other and bring one end up and around the other; b, bring end through the loop; c, dress all four strands; d, pull all four strands tight.

Fisherman's Bend

The fisherman's bend is used to join two ropes together. To tie it, overlap a loose end of each rope and tie each end in an overhand knot around the other rope's standing end (fig. 9-9). While no longer used for climbing, the single fisherman's bend is shown here to provide a clearer understanding of the double fisherman's bend. Note that the barrel knot is the fisherman's tied on a single strand; see Figure 11-13 in Chapter 11, Rappelling.

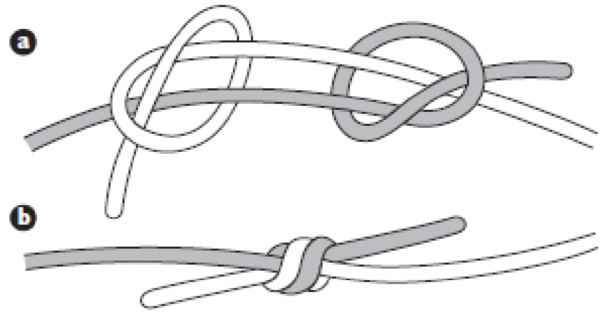

Fig. 9-9. Fisherman's bend: a, overlap a loose end of each rope, and tie each end in an overhand knot around other rope's standing end; b, pull all four strands tight.

Double Fisherman's Bend

The double fisherman's bend, also known as the grapevine knot, is used to join two ropes or both ends of a rope together. To tie it, overlap a loose end of each rope and pass each loose end twice around the other rope's standing end before pulling each end through both its two loops (fig. 9-10a) and then pulling both knots tight (fig. 9-10b). This is a very secure knot for tying the ends of two ropes together for a rappel or for tying secure loops in round cords. It is important to ensure that the two parts of this knot are symmetrical. This can be tested by checking that one side of the knot has four neat parallel strands of rope (fig. 9-10c) and that the other side has two Xs (the knot itself, see Figure 9-10b) neatly nested together.

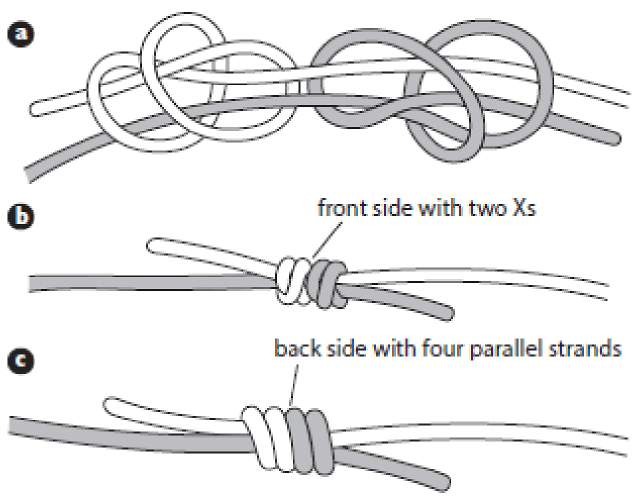

Fig. 9-10. Double fisherman's bend: a, pass each loose end twice around the other rope's standing end and then tie an overhand knot; b, pull all four strands tight; c, back side of correctly tied double fisherman's.

Triple Fisherman's Bend

This knot is similar to the double fisherman's bend (see Figure 9-10), but the loose end goes around the other rope's standing end three times instead of twice. The triple fisherman's bend is preferred when low-friction materials such as Spectra cord are joined together.

Figure Eight on a Bight

The figure eight on a bight (fig. 9-11) is a strong knot that can be tied rapidly. It is commonly used to back up a clove hitch attachment to an anchor in multipitch rock climbing or to tie in to the middle of a rope in glacier climbing.

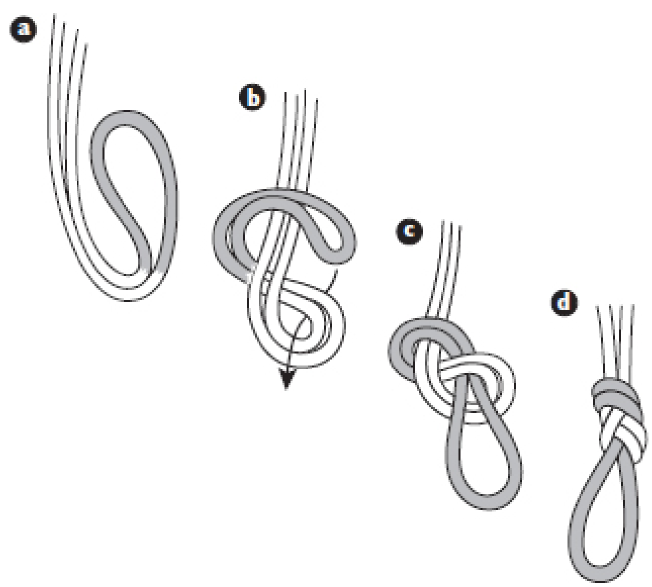

Fig. 9-11. Figure eight on a bight: a, bring a bight back parallel to the standing ends; b, bring bight under and then over the ends, forming an eight, then bring the bight down through the bottom loop of the eight; c, dress the strands; d, pull all four strands tight.

Rewoven Figure Eight

The rewoven figure eight is an excellent knot for tying the end of the rope in to a seat harness. The loose end of a figure eight (fig. 9-12a) is passed around the padded waist belt and leg loops and above the keeper strap, then rewoven (fig. 9-12b and c). The harness's keeper strap "keeps" the rope from slipping around or down a leg loop strap. Finish off the knot by tying an overhand knot in the loose end of the rope. Note that the overhand knot is just a way to keep the tail in place. It does not add security or safety to the knot. The tail of the knot needs to be about the same length as the knot itself to ensure the security of the knot.

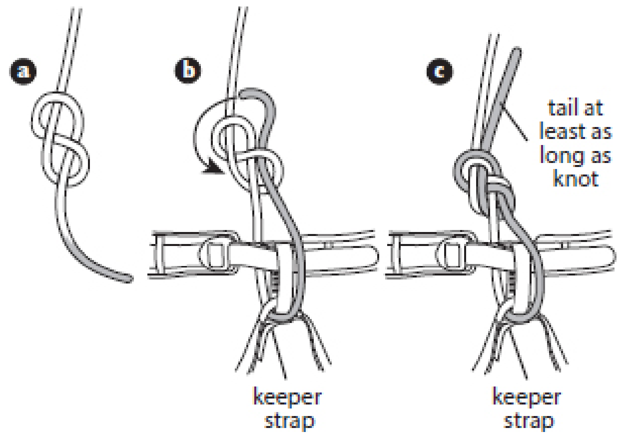

Fig. 9-12. Rewoven figure eight: a, tie a figure eight; b, double the loose end back and retrace the eight so the loose end is parallel to the standing end; c, pull both the ends of the loop and the end loop tight.

Figure-Eight Bend

The figure-eight bend may be used to join two ropes together for rappelling or to create a cordelette or equalette for building anchors (see Chapter 10, Belaying). Tie a figure eight in the loose end of one rope (fig. 9-13a). Use the loose end of the other rope to retrace the figure eight, going toward the standing end of the first rope (fig. 9-13b, c, and d). *Caution: Do not accidentally tie an offset figure-eight bend by matching the two loose ends side by side and tying a figure eight with the two strands; this is very dangerous to use for a rappel.* After being weighted, the figure-eight bend is easier to untie than the double fisherman's bend.

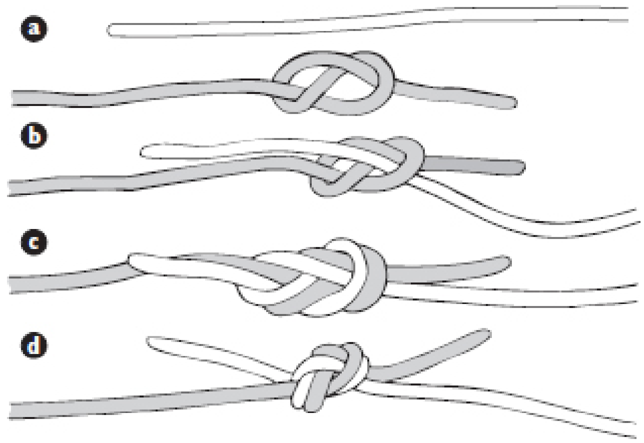

Fig. 9-13. Figure eight bend: a, tie a figure eight in the loose end of one rope; b and c, retrace the eight using the other rope's loose end; d, tighten all four strands.

Single Bowline

The single bowline makes a loop at the end of the climbing rope that will not slip, and it can secure the rope around a tree or other anchor. The loose end of the rope should come out on the inside of the bowline's loop (the rabbit goes up around the tree and back down the hole, fig. 9-14a and b). Tie off the loose end with an overhand knot (fig. 9-14c and d). This knot is easy to untie after it has been loaded, making it a good choice for a top-rope tie-in. Be aware that the bowline knot is not a secure knot. It tends to loosen when not under constant load; so make sure to leave a long tail when you tie the knot and frequently inspect it.

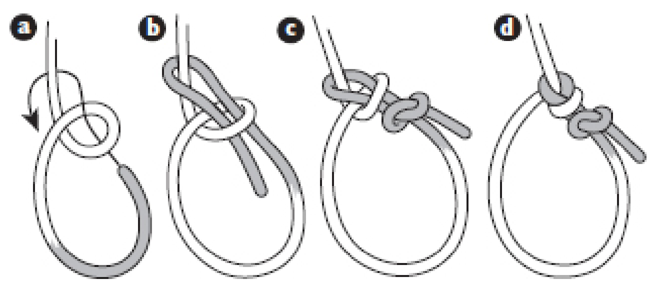

Fig. 9-14. Single bowline: a, make a loop and pass the loose end of the rope under and through it, then around the back of the standing end; b, bring the loose end back down through the loop; c, pull ends tight and tie an overhand knot; d, dressed and backed-up knot.

Single Bowline with a Yosemite Finish

The single bowline with a Yosemite finish, as popularized by Yosemite climbers, is started (fig. 9-15a) the same as a single bowline, but the loose end retraces the rope until it is parallel with the standing end (fig. 9-15b), avoiding the need to tie off the single bowline with an overhand knot (fig. 9-15c).

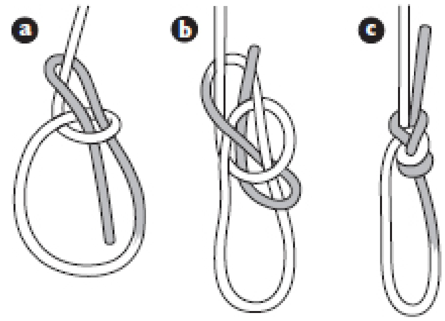

Fig. 9-15. Single bowline with a Yosemite finish: a, tie a single bowline, keeping the knot loose; b, bring the loose end under and over the rope and under the entire knot, then up through the bowline's topmost loop; c, pull all four strands tight.

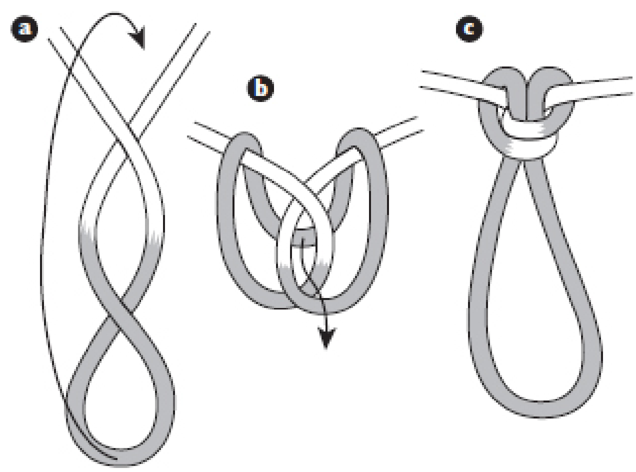

Fig. 9-16. Butterfly knot: a, form a double loop; b, pull the lower loop over and then back down through upper loop; c, pull loop and both strands tight.

Butterfly Knot

The butterfly knot is formed in the middle of a rope by making two loops (fig. 9-16a) and then pulling the end-most loop over and through the other loop (fig. 9-16b). The useful characteristic of the butterfly knot is that it can sustain a pull on either end of the rope or the loop (fig. 9-16c) and not come undone. A connection to this knot is made with a locking carabiner through the loop. It is commonly used to tie in to the middle of a rope for glacier climbing. The American Mountain Guides Association (AMGA) recommends using two locking carabiners, opposite and opposed, when using this knot to tie in to the middle of a rope.

Clove Hitch

The clove hitch, formed by making two loops side by side (fig. 9-17a) and then stacking one loop behind the other (fig. 9-17b), is a quick knot for clipping in to a locking carabiner (fig. 9-17c) attached to an anchor (fig. 9-17d). The main advantage of the clove hitch is that the knot makes it easy to adjust the length of the rope between the belayer and the anchor without unclipping the rope from the carabiner. *Make sure to dress this knot by tightening both strands firmly. If the knot is correctly tied, it will stop the pull when loaded.*

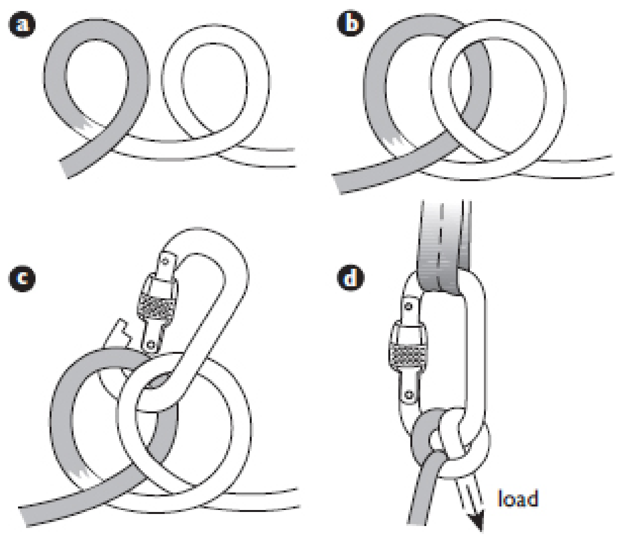

Fig. 9-17. Clove hitch: a, form two identical loops, side by side; b, bring left-hand loop behind the other; c, clip a locking carabiner through both loops; d, pull both ends tight.

Girth Hitch

The girth hitch (fig. 9-18a) is a simple knot that can serve a variety of purposes, such as attaching webbing or cord to a natural anchor or to a pack's haul loop (fig. 9-18b). It can also be used to tie off a short-driven piton (see Figure 13-9 in Chapter 13, Rock Protection).

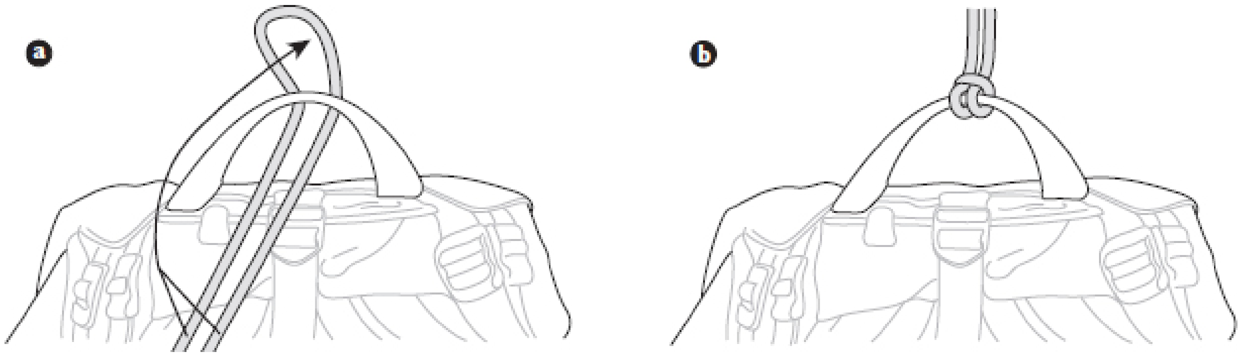

Fig. 9-18. Girth-hitch: a, reach a bight behind or around an object and pull both ends of webbing or cord through the bight; b, dressed webbing or cord girth-hitched around a pack's haul loop.

Overhand Slipknot

The overhand slipknot is another simple knot, formed by making a loop (fig. 9-19a), then bringing a bight up through the loop and drawing it closed to tie off the bight (fig. 9-19b). This knot may be used to attach a tie-off loop (see "Runners" below) or one end of a personal anchor (see "Personal Anchors" below) to a carabiner. The overhand slipknot has the added benefit of immobilizing a runner's knot or sewn bar tacks on the carabiner (fig. 9-19c). Like the girth hitch, it can also be used to cinch a runner to a rock feature or to tie off a short-driven piton.

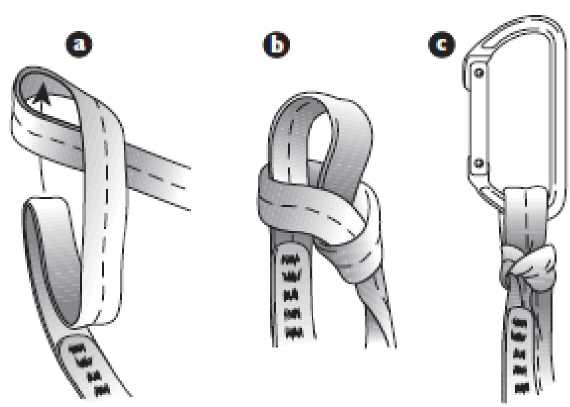

Fig. 9-19. Overhand slipknot: a, make a loop, then bring a bight up through the loop; b, draw loop closed to tie off bight; c, clip bight into a carabiner and pull both ends tight.

Mule Knot

The mule knot is used to temporarily free the belayer's hand and also is a useful temporary tie-off when stopping during a rappel. In an emergency, it can be used to tie off a belay to a fallen climber so that both hands may be safely used to set up an anchor and/or free the belayer from the climbing rope (see “Escaping the Belay” in Chapter 10, Belaying).

When used with a belay device, this knot is called a *device-mule.* While holding your braking hand back in the brake position, start by pulling a bight of rope through the locking carabiner on your harness using your free hand (fig. 9-20a); continue to hold the brake with your other hand. Pull the bight behind the loaded strand of rope going to the fallen climber and twist it to form a loop, then fold another bight of rope over the loaded strand and push it through the loop (fig. 9-20b). Remove any slack and pull the knot tight by pulling on the upper strand (fig. 9-20c); back up the device-mule with an overhand knot tied around the loaded strand (fig. 9-20d).

When using a munter hitch belay (this hitch is described below), the mule knot is called a *munter-mule.* Hold the fallen climber with your braking hand and make a loop in the rope on the same side as your braking hand. With your free hand, pull some slack rope behind the loaded strand of rope going to the climber and make a bight (fig. 9-21a). Fold the bight over the rope and push it through the loop, then tighten the knot by pulling on the upper strand (fig. 9-21b). Pull additional slack through the mule knot as needed by pulling on the lower strand; back up the munter-mule with an overhand knot around the climbing rope (fig. 9-21c).

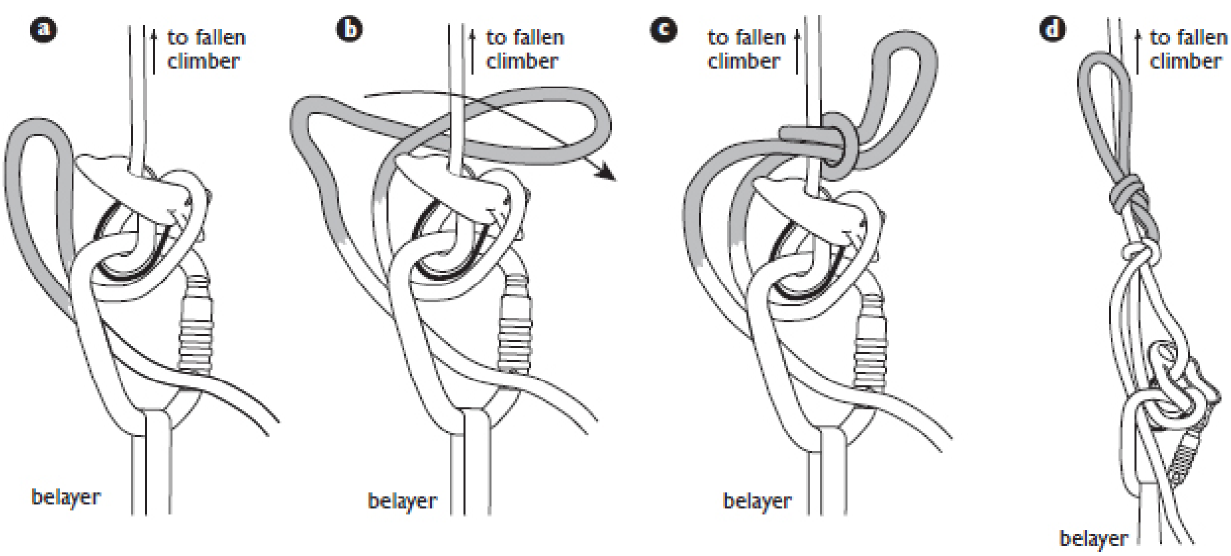

Fig. 9-20. Mule knot with belay device (device-mule): a, pull a bight of rope through the locking carabiner; b, pull the bight behind the loaded strand and form a loop, then fold another bight over the front of the loaded strand and push it through the loop; c, remove slack and tighten knot by pulling on the upper strand; d, back up with an overhand knot tied around the loaded strand, pulling on the lower strand if more rope is needed.

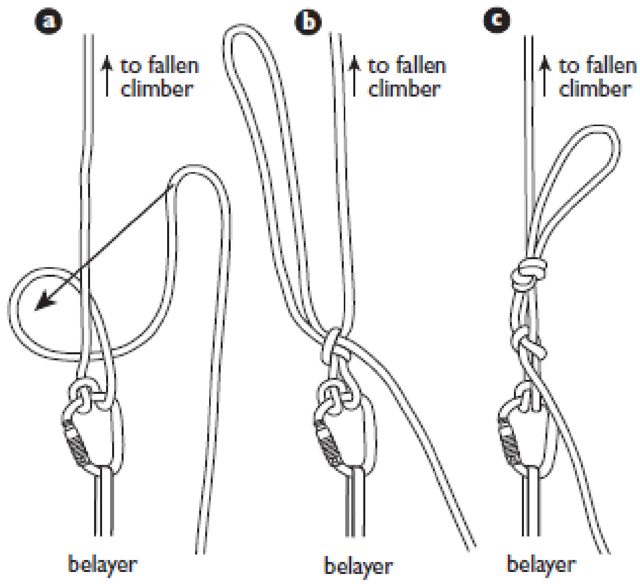

Fig. 9-21. Mule knot with munter hitch (munter-mule): a, make a loop under the loaded strand, then take a bight and fold it around the loaded strand and through the loop; b, tighten the knot by pulling on the upper strand; c, back up with an overhand knot around the loaded strand, pulling on the lower strand if more rope is needed.

FRICTION HITCHES

Friction hitches are a quick and simple way to set up a system for ascending or descending a climbing rope without the use of mechanical ascenders or for backing up a rappel. Hitches grip the climbing rope when weight is placed on them but are free to move when the weight is released. The best-known friction hitch is the prusik, but others, such as the bachmann, the klemheist, and the autoblock, are also useful.

Prusik Hitch

For the prusik hitch, an accessory cord loop is attached to the climbing rope via a girth hitch (fig. 9-22a), followed by a few additional wraps around the climbing rope (fig. 9-22b and c). For use on a climbing rope, a tie-off loop of 5-to 7-millimeter accessory cord, for example, is wrapped twice (fig. 9-22d) or three times (fig. 9-22e) around the rope. Icy ropes, thinner-diameter ropes, or heavy loads require more wraps of the hitch to ensure sufficient friction to hold the load.

To create the necessary friction, the cord must be smaller in diameter than the climbing rope; the greater the difference in diameter, the better the hitch grips. However, very small-diameter cords make the prusik hitch more difficult to manipulate than do cords of larger diameter. Experiment to see which diameter of cord works best. Webbing is not usually used for prusik hitches because it provides less friction than cord.

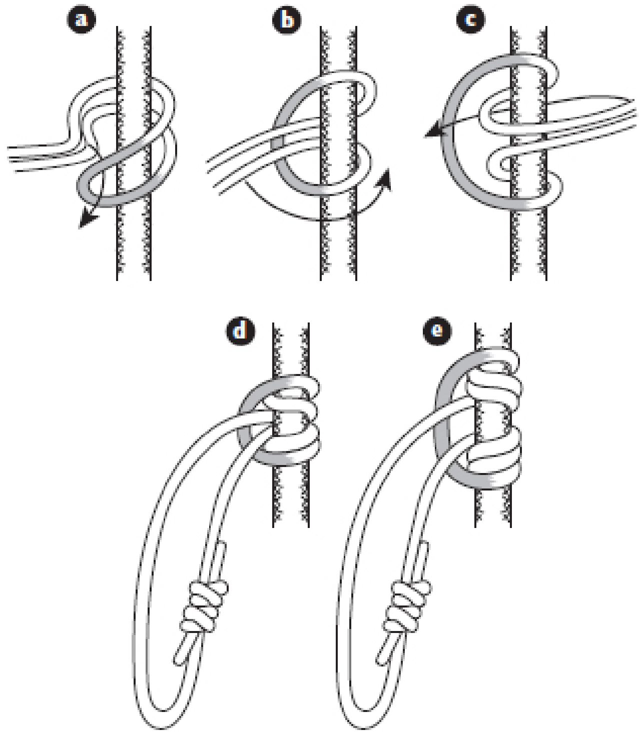

Fig. 9-22. Prusik hitch: a, girth-hitch cord around rope; b, bring loose ends of cord around rope and under cord; c, wrap loose ends around rope again; d, two-wrap prusik hitch; e, three-wrap prusik hitch.

By attaching two cords to a climbing rope with prusik hitches, you can ascend or descend the climbing rope. Chapter 18, Glacier Travel and Crevasse Rescue, explains the Texas prusik method of ascending the rope using prusiks. The prusik hitch is also used as part of the rescue systems needed to raise and lower people and equipment during rescues, and to pass safety knots in the rope. These systems are also described in Chapters 18 and 25, Alpine Rescue.

Bachmann Hitch

The bachmann hitch is used for the same purposes as a prusik hitch. The bachmann hitch is tied around a carabiner and the climbing rope (fig. 9-23), which makes the bachmann much easier to loosen and slide than a prusik. The bachmann hitch has the virtue of sometimes being “self-tending” (it will feed rope in the non-load-bearing direction without requiring you to actively manipulate it).

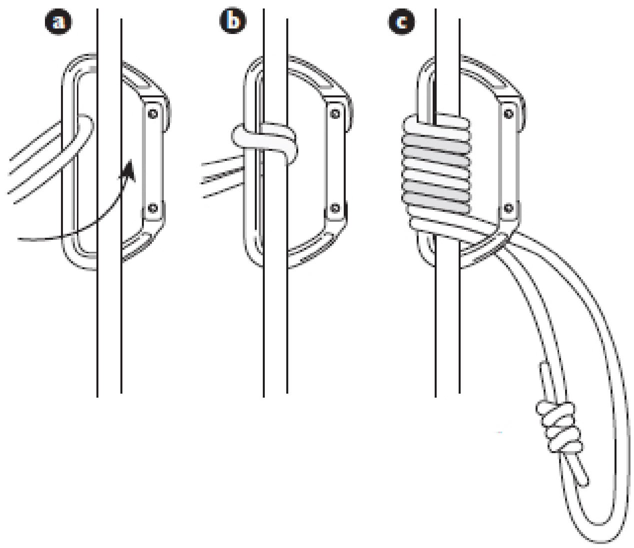

Fig. 9-23. Bachmann hitch: a, with a carabiner under the rope, clip a loop of cord in to carabiner; b, wrap cord around rope and clip through carabiner; c, repeat three to five times.

Klemheist Hitch

The klemheist hitch is another alternative to the prusik, with the advantage that it can be made from either accessory cord or webbing, which may become important if you are caught with an ample supply of webbing but little cord. A tied loop of cord or webbing is wound around the main rope in a spiral and then threaded through the loop created by the top wrap of the cord or webbing (fig. 9-24a). Pull down to create the basic klemheist (fig. 9-24b), which can be clipped to a carabiner (fig. 9-24c). The tied-off klemheist (fig. 9-24d) is less likely to jam and easier to loosen and slide than the basic klemheist. The klemheist can also be tied around a carabiner (fig. 9-24e), which provides a good handhold for sliding the knot along the rope.

Autoblock Hitch

The autoblock hitch is similar to the klemheist. In general, the autoblock is easier than the prusik to release once it has been loaded, but it doesn't provide as much friction. It is meant to simulate the grip of a hand rather than support full body weight. The autoblock hitch is tied using a short loop of cord or webbing. When using it for self-belay when rappelling with extension, wrap the cord three or more times around the rope to provide friction (fig. 9-

25a–c), and then clip both ends into a carabiner attached to the belay loop of the harness (fig. 9-25d and e). For rappelling without extension, the carabiner should be attached to a leg loop instead. If using the rappel extension, then both ends of the autoblock would be clipped directly in to the harness carabiner (see Figure 11-21 in Chapter 11, Rappelling).

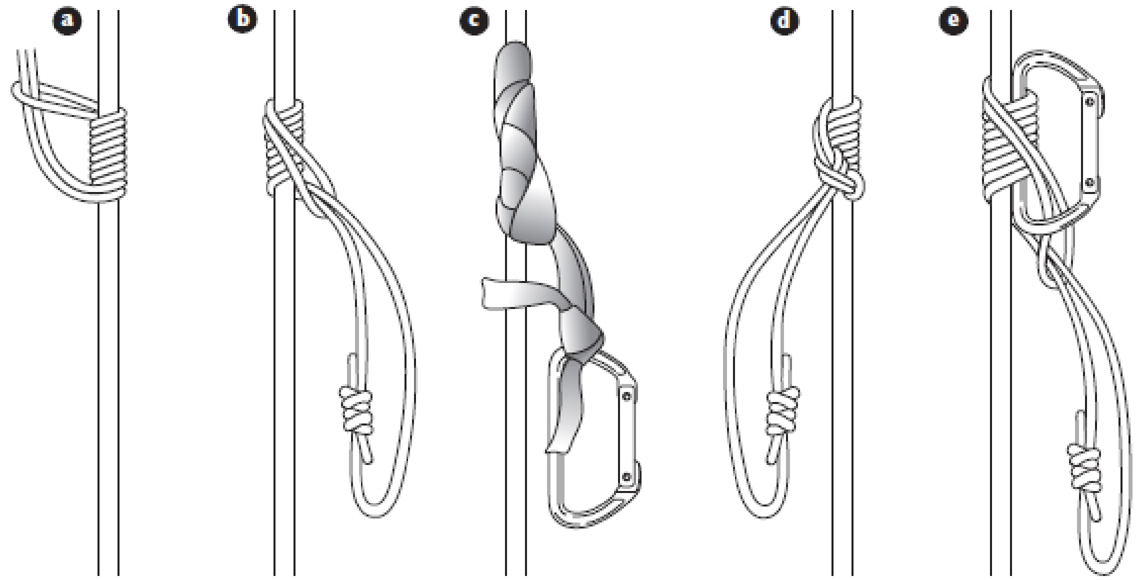

Fig. 9-24. Klemheist hitch: a, wrap a loop of cord around the rope five times and draw loose ends through the end loop; b, pull ends down; c, klemheist hitch tied using webbing and clipped to a carabiner; d, klemheist hitch tied off—bring ends up, then under and over the loop, forming a new loop, and then down through this loop, pulling the ends tight; e, klemheist tied around a carabiner.

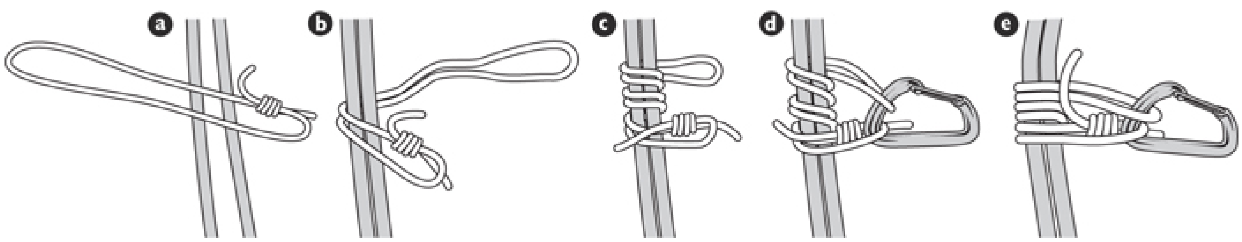

Fig. 9-25. Autoblock hitch: a, lay a loop of cord, tied with a double fisherman's bend near one end, perpendicular to the climbing rope; b, wrap the cord around the rope; c, wrap three times; d, clip both ends of the cord to a carabiner; e, dress the knot, making sure there are no twists or overlapping strands and that the double fisherman's bend is neither in the wrap nor squarely on the carabiner.

Munter Hitch

The munter hitch (originally dubbed the *halbmastwurf sicherung*, meaning "half clove-hitch belay," abbreviated as HMS) is very easy to set up and use, but it feeds rope effectively only if used on a “pear-shaped” HMS locking carabiner (pearabiner)—that is, a carabiner large enough at its wider end to accommodate multiple turns of the rope. The munter is a simple hitch in the rope that is clipped in to an HMS carabiner (fig. 9-26a and b) to create friction (fig. 9-26c).

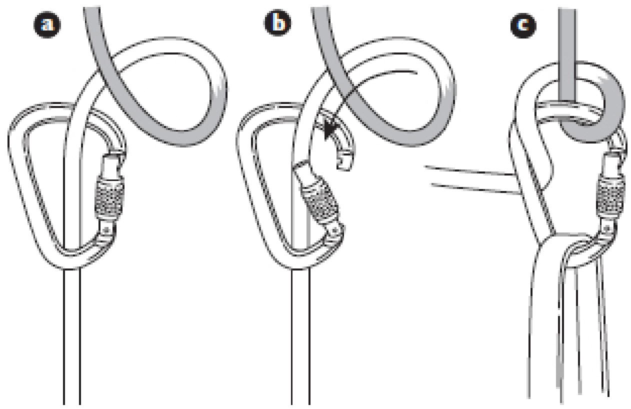

Fig. 9-26. Munter hitch: a, draw rope up through carabiner and form a loop; b, clip carabiner through loop; c, pull ends in opposite directions.

The munter hitch is an excellent method of belaying a leader or lowering a climber, because the hitch is reversible (the rope can be fed out of the carabiner, or the rope can be pulled back in through the carabiner) and the knot provides sufficient friction for the belayer to stop a falling or lowering climber by holding the braking end of the rope. The munter hitch can also be used for rappelling, though it puts more twist in the rope than other rappel methods. Even if you prefer to use a specialized belay device, this hitch is worth knowing as a backup if you lose or forget your belay device.

HELMETS

Climbing helmets help protect your head from rockfall and from gear dropped by climbers above you. Helmets also protect you from the many ways in which you can suddenly hit hard surfaces such as rock or ice: a fall to the ground, a leader fall that swings you into a wall, or a quick move upward against a sharp outcropping. However, keep in mind that no helmet can protect you from all possible impacts.

Modern climbing helmets are lightweight, ventilated, and available in many designs. Buy a climbing helmet with UIAA and/or CEN certification, which ensures minimum standards of impact resistance.

Hardshell helmets. Also called suspension or hybrid helmets, hardshell helmets (fig. 9-27a) have a thick, hard outer shell, usually ABS plastic, covering a small bit of polystyrene foam combined with a suspension system. The ABS shell is very durable and resistant to dings. Hardshell helmets are suitable for all styles of climbing, including ice, alpine rock, and aid climbing.

Lightweight foam helmets. Constructed primarily of polystyrene covered in a thin polycarbonate shell (or in rare cases, foam covered with no shell at all), lightweight foam helmets (fig. 9-27b) dissipate impact forces via deformation. These helmets are typically lighter and more ventilated than hardshell helmets. Because they lack an outer shell, lightweight foam helmets are not as long lasting, need to be handled more carefully, and may need to be replaced more often. For these reasons, they are probably better suited for experienced climbers.

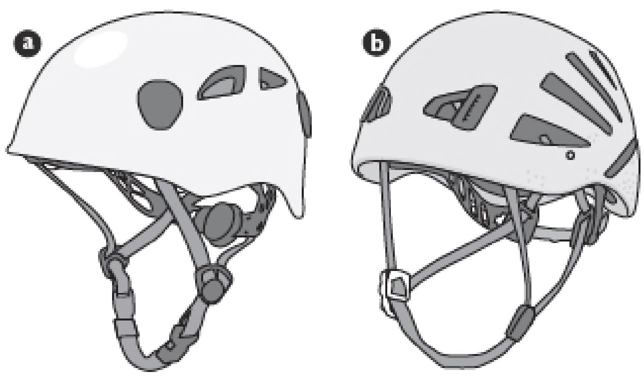

Fig. 9-27. Climbing helmets: a, hardshell helmet; b, lightweight foam helmet.

How to choose a helmet. Before picking out a helmet, consider the type of climbing you plan to do. For example, helmets with large air vents add comfort on hot days but do not protect as well against smaller rocks or other projectiles. Most helmets have clips for headlamps (fig. 9-27b), but check for this feature. Because normal skull shapes and sizes vary, fit is individual. Try on many different styles and brands. Choose a helmet that fits well and that can be adjusted to fit whether you are bareheaded or wearing a hat or balaclava. To protect your forehead and frontal lobe, make sure to wear the helmet so it is riding forward (fig. 9-28a), not tipping back (fig. 9-28b).

When to replace a helmet. Climbing helmets have a limited life span. Even with minimal use, they should be retired no later than 10 years after the date of manufacture (stamped on some brands), and frequent climbers may want to cut this time in half. Even with ultraviolet radiation inhibitors, the plastics in helmets are vulnerable to sunlight and weaken with exposure; helmets can be damaged and not show obvious wear and tear. Retire a helmet when it is obviously dented, cracked, or damaged or the straps are worn or torn. It is recommended that a helmet be replaced as soon as possible after a significant impact: any time you take a hard hit and think to yourself, “I would have been seriously hurt if not for my helmet,” the helmet has done its job and it is time to get a new one.

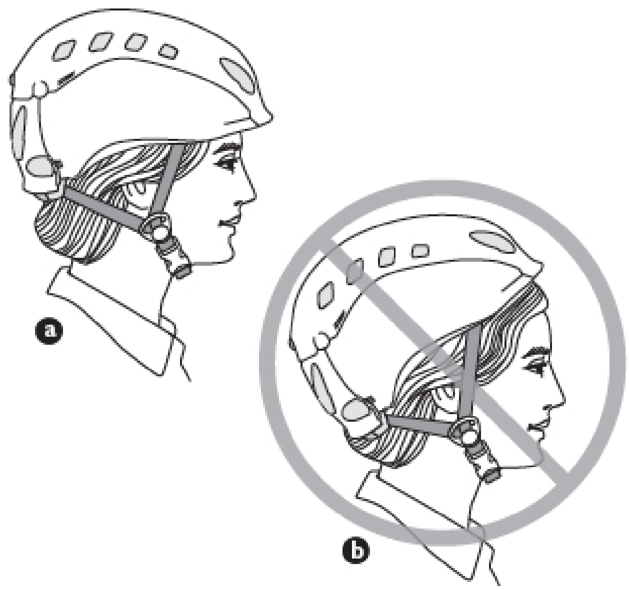

Fig. 9-28. Wearing a helmet: a, properly adjusted; b, adjusted incorrectly, leaving forehead exposed to rockfall and icefall.

To maximize the life of your helmet, protect it from banging against hard surfaces when not on your head, which makes it vulnerable to chipping and cracking. Follow manufacturers’ recommendations for storage, which for helmets includes avoiding leaving them under a window or in the trunk of a car. Follow these steps each time before storing your helmet:

- Test to see that the chin buckle and adjustment hardware are in good working order.
- Check whether the suspension or other webbing is in good shape and free of frays and tears.
- Make sure any foam casing is secure, and that all components are free of cracks and dents. Minor dings are okay; major dents are not.

HARNESSES

In the early days of climbing, the climbing rope was looped around a climber's waist several times and then the waist loop was tied in to the rope with a bowline on a coil. That practice is no longer considered safe because long falls onto waist loops can severely injure a climber's back and ribs. Additionally, falls that leave the climber hanging, such as a fall into a crevasse or over the lip of an overhang, could cause the rope to ride up and constrict the climber's diaphragm, leading to suffocation. Improvising leg loops and attaching them to the whole coil can help prevent injury, but the bowline on a coil is best avoided except for emergencies.

Today, climbers connect to the rope using a harness designed to distribute the force of a fall over a larger percentage of the climber's body. A climber at either end of a climbing rope ties in to the harness with a knot such as the rewoven figure eight (see Figure 9-12) or a single bowline with a Yosemite finish (see Figure 9-15). A climber in the middle of a rope usually ties in to the harness with a butterfly knot (see Figure 9-16) or a figure eight on a bight (see Figure 9-11).

Harnesses deteriorate over time; they should be inspected often and replaced with the same frequency as a climbing rope. The bowline on a coil remains an option for emergency use if no harness or harness material is available, but an improvised diaper sling (see below) would be a better choice.

SEAT HARNESSES

With properly fitted leg loops, a seat harness rides snugly above your hip bones yet transfers the force of a fall over your entire pelvis. It also provides a comfortable seat during rappelling. Throughout this book, when not otherwise specified, "harness" refers to a seat harness.

Manufactured Seat Harness

Several features are particularly desirable in a mountaineering seat harness (fig. 9-29). Adjustable leg loops maintain a snug fit no matter how few or how many layers of clothing you are wearing. Padding on the waist belt and leg loops can provide additional comfort, particularly if you will be hanging for any length of time, although padding adds to the bulk and weight of the harness. Leg loops that can be unbuckled or unclipped from the backside of the harness permit toilet calls without your having to remove the harness or untie from the rope. A belay loop can make it easier to attach a belay device for belaying or rappelling, while having the waist buckle located toward one side helps avoid conflict with the rope tie-in or with the locking carabiner that you attach to the harness for use in belaying and rappelling in the absence of a belay loop. Gear loops are desirable for carrying carabiners and other pieces of climbing gear.

Before buying a harness, try it on to be sure the harness fits properly over your climbing clothes. With the profusion of harness styles on the market, you must consult each manufacturer's instructions to learn how to safely wear and tie in to that particular harness. Printed instructions accompany any new harness, and they also are usually sewn inside the waist belt. For some harnesses, you must pass the waist strap back over and through the main buckle a second time for safety (on these models, you must usually do the same for the leg loop straps and buckles). Be sure at least 2 to 3 inches (about 5 centimeters) of strap extends beyond the buckle after you reweave the strap.

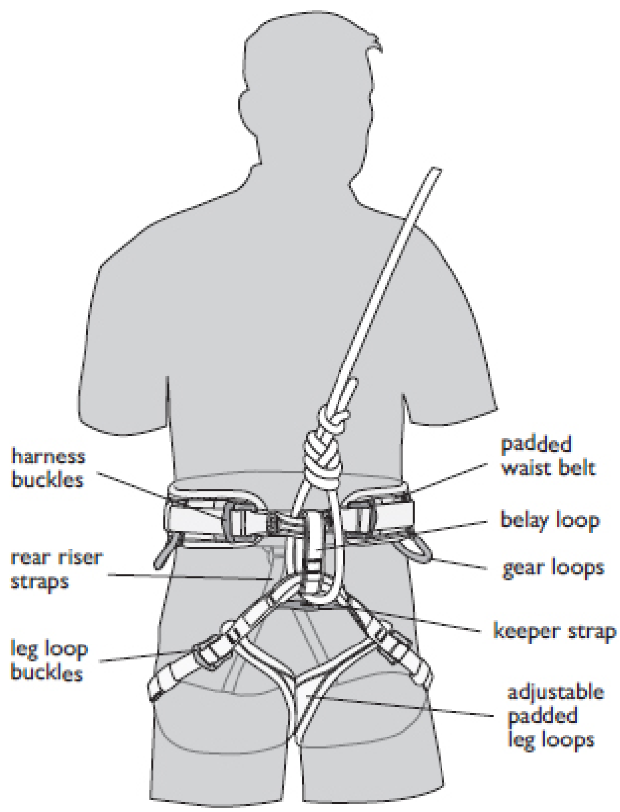

Fig. 9-29. Seat harness with common features.

Diaper Sling

In an emergency, a diaper sling may be improvised as a seat harness. The diaper sling takes about 10 feet (3 meters) of webbing tied in a large loop. With the loop behind your back, pull each end around your sides to your stomach (fig. 9-30a). Bring one piece of the webbing loop down from behind your back and between your legs, then up to your stomach to meet the other two loop ends (fig. 9-30b). Clip them together in front with two opposite and opposed carabiners (see Figure 9-37a) or a locking carabiner (fig. 9-30c). The diaper sling may also be clipped to a safety loop made of webbing tied around your waist.

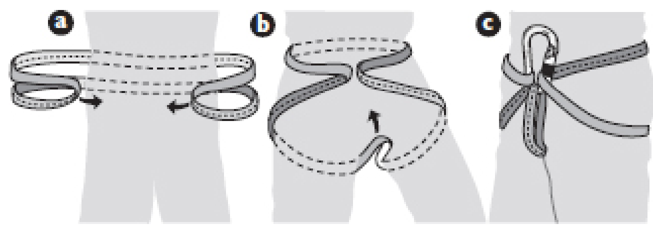

Fig. 9-30. Diaper sling: a, bring large loop around waist from the back; b, bring one piece of loop behind back down through the legs and up; c, clip all three parts together with a locking carabiner (shown here) or two opposite and opposed carabiners.

A description of how to build a homemade seat harness can be found in a book for professional rescuers: *Technical Rescue Riggers Guide*, by Rick Lipke (see Resources). The homemade seat harness is not a substitute for the effective reliability of a modern commercial seat harness, but the knowledge of how to build one could be useful in an emergency if the requisite amount of tubular webbing is available.

Personal Anchors

On multipitch alpine rock climbs, most climbers use the climbing rope itself to tie in to the anchor (see “Tying In to the Anchor” in Chapter 10, Belaying). Nevertheless, it is sometimes necessary to use a personal anchor or leash to attach yourself to belay and rappel anchors while you set up and tear down the belay, the rappel, and/or the anchor. Use a runner, usually double-length (see “Runners” below), and girth-hitch one end to the seat harness, following the same path with the runner as you would to tie the climbing rope to your harness. Add a locking carabiner to the other end of the runner for connecting to the anchor.

When not in use, the personal anchor can be wrapped around your waist and clipped to the seat harness or otherwise neatly stowed on the seat harness. Commercial personal anchors are available that are made of a series of full-strength loops, so the system can be shortened and lengthened.

Daisy chains are sometimes used as personal anchors, but they are dangerous if used incorrectly. They are made for aid climbing (see Chapter 15, Aid and Big Wall Climbing), and the stitches of the sewn links are rated for body weight only. If a climber cross-clips only a sewn link (that is, clips in to the anchor through two loops of the daisy chain), a fall can break the relatively weak bar tacks separating the loops and completely detach the climber from the anchor. The result can be catastrophic failure.

CHEST HARNESS

A chest harness helps keep a climber upright after a fall or while ascending a rope using prusiks or mechanical ascenders. Following a fall, simply clip the climbing rope through the carabiner of the chest harness, which provides stability and assists you in staying upright. The chest harness will deliver some of the force of a fall to your chest, which is more easily injured than your pelvis (where the force is directed by a seat harness). Thus, a rope is not usually clipped in to the chest harness during rock climbing or general mountaineering. Some snow or glacier climbers travel with the rope passing up through a carabiner on the chest harness, but this is not recommended, because if the climber must arrest and hold a fall, the force will come high on the body and could spin the climber out of arrest position. It is therefore preferable to leave the rope unclipped until a crevasse fall actually occurs (see Chapter 18, Glacier Travel and Crevasse Rescue). The chest harness is also useful when rappelling with a heavy backpack to help the climber stay upright.

A chest harness may be purchased or is readily improvised with a long loop of webbing (a long runner). One popular design depends on a carabiner to bring the ends of the harness together at your chest. To make a carabiner chest harness, start with 9.5 feet (2.9 meters) of 9/16-inch or 1-inch tubular webbing. Use a distinctive color of webbing to distinguish the chest harness from other double-length runners (see "Runners" below). Tie the webbing into a loop with a water knot; adjust the size of the webbing loop to fit comfortably. Give the loop a half twist to create two temporary loops, and push one arm all the way through each loop. Lift the runner over your head and let it drop against your back, with the crossed portion at your back (fig. 9-31a); then pull the two sides together in front and clip with a carabiner at your chest (fig. 9-31b). Keep the knot in front of you and out of the way of the carabiner.

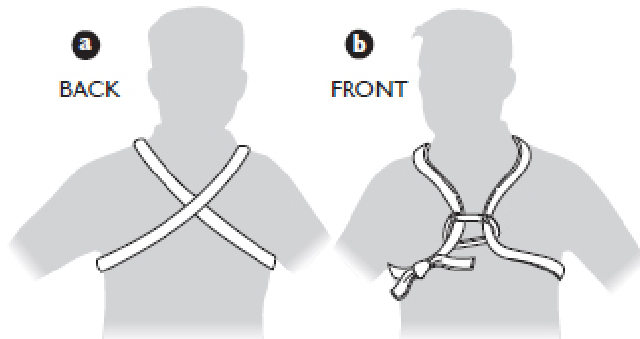

Fig. 9-31. Carabiner chest harness: Using a loop of webbing made with a water knot, twist the loop and put your arms in the two new loops; a, lift the runner over your head and let the crossed portion drop against your back; b, clip a carabiner through the two front sides.

FULL-BODY HARNESS

Full-body harnesses, which incorporate both a seat harness and a chest harness, have a higher tie-in point (fig. 9-32). This reduces the chance of your flipping over backward during a fall. Because a body harness distributes the force of a fall throughout the trunk of your body, there may be less danger of lower-back injury.

Although in some circumstances body harnesses may be safer, they have not found popular favor in mountaineering. They are not recommended for glacier travel for the reason mentioned above: if a climber must arrest to hold a fall, the force will come high on the body and could spin the climber out of arrest position. Body harnesses are more expensive, more restrictive of movement, and make it hard to add or remove clothing. Instead, most climbers use a seat harness and then improvise a chest harness when one is warranted, such as when climbing with a heavy pack, crossing glaciers, or aid climbing under large overhangs. However, full-body harnesses are necessary for children whose hips are not yet fully developed, because they could slide out of the seat harness if they become inverted. Full-body harnesses are also recommended for pregnant women, a decision which a climber should make in consultation with her physician.

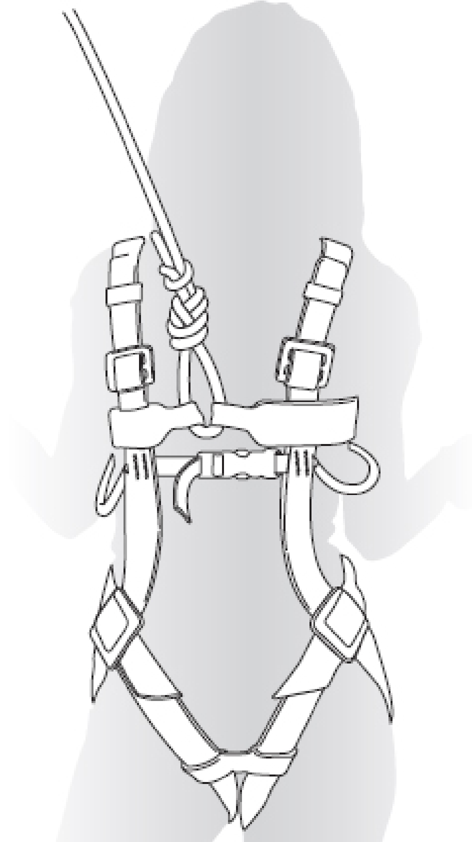

Fig. 9-32. Full-body harness.

RUNNERS

Loops of tubular webbing or round accessory cord, called *runners* or *slings*, are among the simplest pieces of climbing equipment and among the most useful. (Note that flat webbing differs from tubular webbing: flat webbing is used for things like pack straps, while tubular webbing—so-called even though it lies flat—is used in climbing-specific applications.) Runners are a critical link in climbing systems. Standard single runners require 5 feet (1.5 meters) of webbing or cord. Double-length runners require 9 feet (2.7 meters) of webbing or cord. Triple-length runners require 13 feet (3.9 meters) of webbing or cord. After being sewn or tied into loops, the standard lengths become 2 feet (0.6 meter), 4 feet (1.2 meters), and 6 feet (1.8 meters) for single-, double-, and triple-length runners, respectively. A beginning climber should own many single runners and a few doubles.

To help you quickly identify the different lengths, it is useful to use single runners of one color of webbing, double runners of another color, and triple runners of a third color. For a tied webbing runner, it is useful to write your initials and the date the runner was made on one of the tails of the water knot. Identifying the runner and its age helps in deciding when to retire it. Runners should be retired regularly, using the same considerations as for retiring a rope or harness (see those sections above).

It is very important to remember that webbing and accessory cord do not have dynamic characteristics. If they are used without a dynamic rope, a fall of even a few feet can impart catastrophic force onto the anchor system and climber (see "Limiting Impact Force with Dynamic Rope" in Chapter 10, Belaying).

Sewn. High-strength, presewn runners (fig. 9-33a) can be purchased at climbing stores. Sewn runners come in various lengths: 4-inch (10-centimeter), 6-inch (15-centimeter), 12-inch (30-centimeter, called half-length), 2-foot (0.6-meter, called single-length), 4-foot (1.2-meter, called double-length), and 6-foot (1.8-meter, called triple-length), as well as in sizes between the standard half-, single-, double-, and triple-length runners. Some runners are specially sewn into preformed *quickdraws*, which are typically 4 to 8 inches (10 to 20 centimeters) long, and have carabiners attached at each end (fig. 9-33b). Sewn runners also come in a variety of widths, with 5/16-, 3/8-, 9/16-, 11/16-, and 1-inch (8-, 10-, 14-, 17-, and 25-millimeter) widths the most common.

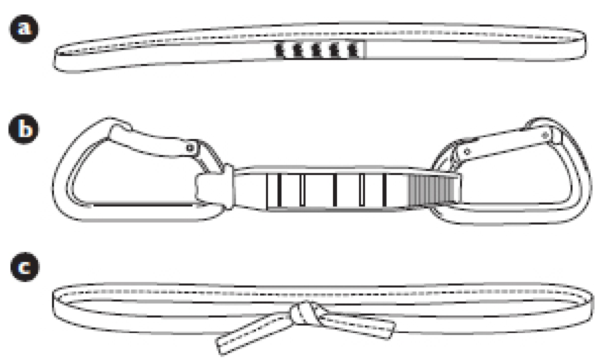

Fig. 9-33. Runners made of webbing: a, sewn runner; b, sewn quickdraw; c, tied runner.

Runners are often made from Dyneema and Spectra, high-performance polyethylene fibers that are stronger, more durable, and less susceptible to ultraviolet deterioration than nylon. However, these materials have a lower melting temperature and provide less friction than nylon, which can affect their use in friction hitches. Sewn runners are generally stronger, usually lighter, and less bulky than tied runners. Using a sewn runner also eliminates the possibility of the knot coming untied, a concern with tied runners.

Tied. Runners can be made by tying a loop in 9/16-to 1-inch tubular webbing or in 7-to 9-millimeter Perlon accessory cord. A webbing runner is usually tied with a water knot (see Figure 9-7) to make the loop (fig. 9-33c). Avoid putting twists into the runner while tying it. A cord runner is typically tied with either a double fisherman's bend (see Figure 9-10) or a triple fisherman's bend, required for Spectra or aramid fiber (Kevlar) cord. Tails on tied runners should be 2 to 3 inches (5 to 7.5 centimeters) long. If the webbing or cord is cut to make the runner, the ends must be melted with a small flame to keep the ends from unraveling.

While bulkier and heavier, tied runners do have several advantages over commercially sewn runners. Tied runners are inexpensive to make, can be untied and threaded around trees and natural chockstones (rocks firmly lodged in cracks), and can be untied and retied with another runner to create longer runners.

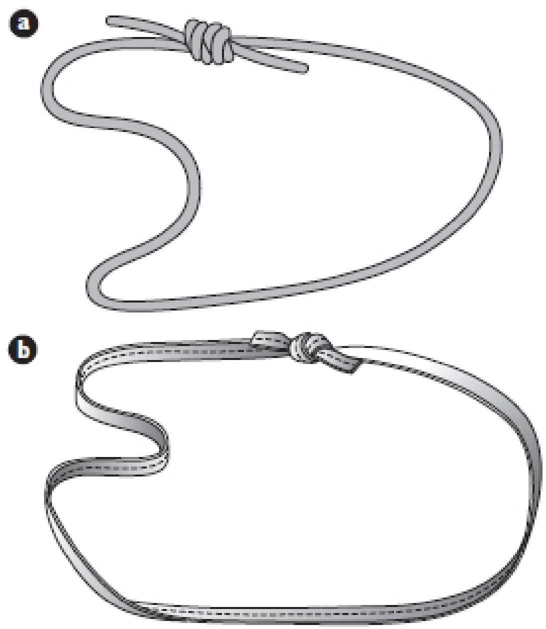

Fig. 9-34. Tie-off loops: a, double fisherman's bend in cord; b, water knot in webbing.

Tie-off loops. Also called *hero loops*, tie-off loops are short runners usually made of 5-to 8-millimeter cord tied into a loop (fig. 9-34a), although a loop of webbing can be used in a pinch (fig. 9-34b). The length of the loop depends on its intended use. They are commonly used for escaping belays (see Chapter 10, Belaying), for self-belay during a rappel (see Chapter 11, Rappelling), for aid climbing (see Chapter 15, Aid and Big Wall Climbing), and for attaching the anchor to the rope in crevasse rescue (see "Crevasse Rescue Response" in Chapter 18, Glacier Travel and Crevasse Rescue).

Load-limiting runners. A climber can effectively limit the maximum impact on individual protection placements by using a load-limiting device (such as the Yates Gear Screamer). A load-limiting runner consists of a sewn runner with a series of weaker bar tacks (fig. 9-35a), usually encased in a sheath (fig. 9-35b); the bar tacks fail at a specific impact force, which reduces high loads, while the runner retains full strength if fully extended (fig. 9-35c shows the runner partially extended).

CARABINERS

Carabiners are another versatile and indispensable climbing tool used for belaying, rappelling, prusiking, clipping in to anchors, securing the rope to points of protection, and numerous other tasks. All modern carabiners are marked with the "working load limit," that is, the force at which the carabiner will fail. At a minimum, a CEN-certified carabiner should have a working load limit of 20 kilonewtons closed gate strength and 7 kilonewtons open gate and minor axis strength. This means that the carabiner should be able to withstand the force of up to a 20-kilonewton pull when its gate is closed—a substantial safety margin over the forces generated by a fallen climber (see "Understanding Fall Factors" in Chapter 10, Belaying).

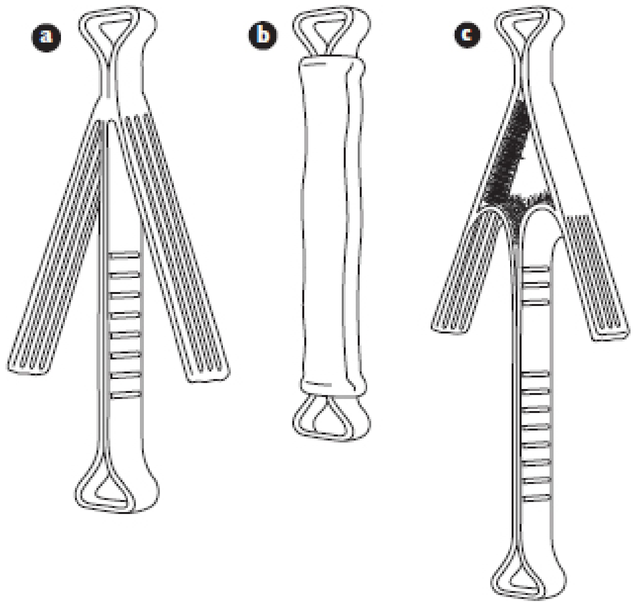

Fig. 9-35. Load-limiting runner: a, constructed with a sewn loop on both ends for clipping to protection; b, usually enclosed in a sheath that reduces abrasion and makes the unit more compact; c, when partially deployed, and even if all the load-limiting bar tacks fail, the runner still retains its full strength and integrity as a closed loop.

SHAPES AND STYLES

Carabiners come in many sizes and shapes. Ovals (fig. 9-36a) were once very popular for general mountaineering because their symmetry makes them good for many purposes. D carabiners (fig. 9-36b) also offer a good general-purpose shape, plus they are stronger than ovals with the same amount of metal because more of the load is transferred to the long axis and away from the gate, the typical point of failure for a carabiner. Offset Ds (fig. 9-36c) have the strength advantage of standard Ds, but the offset D's gate opens wider, making it easier to clip in awkward situations. Bent-gate carabiners (fig. 9-36d) facilitate clipping and allow climbers to quickly clip and unclip the carabiners by the feel of the gates alone; bent-gate carabiners are often used in quickdraws to attach to the rope and bolt hangers for sport climbing.

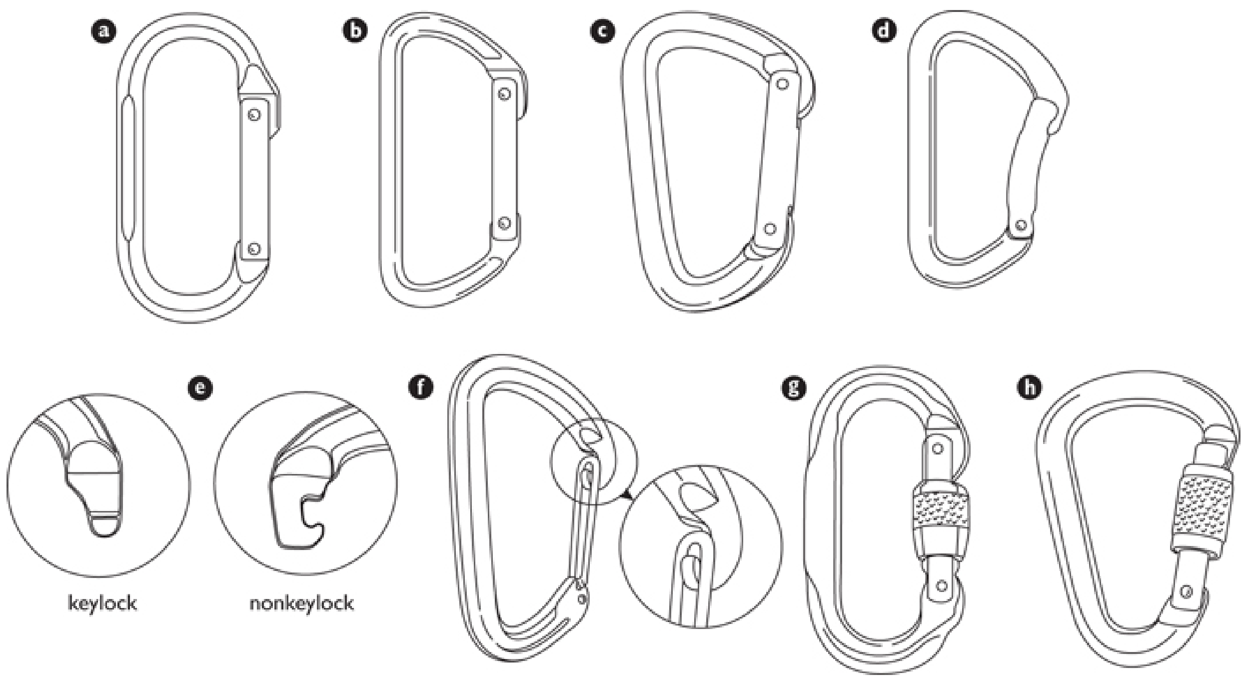

Fig. 9-36. Carabiners: a, oval carabiner; b, standard D carabiner; c, offset D carabiner; d, bent-gate carabiner; e, detail of a keylock latch; f, wire-gate carabiner with detail of nonkeylock latch; g, standard locking carabiner; h, pear-shaped HMS locking carabiner (pearabiner).

Traditionally, the gate of a carabiner connects to the rest of the frame through a latch that creates a hook toward the inside of the carabiner. Because this latch's hook can interfere with unclipping ropes or slings, several models of carabiner now use a keylock connection that doesn't use a hook (fig. 9-36e).

With a trend toward lighter and stronger gear, wire-gate carabiners have become very common (fig. 9-36f). They provide a strong gate at a reduced weight, and they are less prone to freezing shut or having their clipping action become sticky. Some studies also indicate that wire-gate carabiners are less prone to gate fluttering, which can occur when a rope passes quickly through a carabiner during a leader fall.

Some carabiners are made from metal bars with cross sections that are oval, T-shaped or cross-shaped, or wedge-shaped—as opposed to round—in order to save weight. Note that "regular" carabiner refers to carabiners of whatever shape that do not lock.

Locking carabiners. With a sleeve that covers one end of the gate to minimize accidental opening, locking carabiners (fig. 9-36g) provide a wider margin of safety for rappelling, belaying, or clipping in to anchors. Most locking carabiners have a sleeve that screws over one end of the gate. Others have a spring that automatically rotates the sleeve into place whenever the gate is closed, rather than the climber having to screw it down. Regardless of the carabiner's particular locking mechanism, always check to make sure that the carabiner is properly locked. Test it manually before relying on it.

Pear-shaped locking carabiners, also called HMS carabiners (fig. 9-36h), are much larger at the gate-opening end than at the hinge end; they are ideal for belaying with the munter hitch (see Figure 9-26). They are also a good choice for use in conjunction with the seat harness. The extra cost and weight of pear-shaped locking carabiners is justified by the increased ease they provide in loading and managing all the ropes, knots, cords, and runners that are used at the seat harness's anchor point.

Two regular carabiners can be substituted for a locking carabiner, but only if they are joined correctly. Align the gate side of each carabiner with the spine side of the other, so their gates are on opposite sides. The gate-opening ends should face the same direction, so the two gates open toward—or opposed to—each other (fig. 9-37a). This opposite and opposed configuration helps prevent the carabiners from being forced open and accidentally unclipping (as they could if configured as in fig. 9-37b, c, or d). You can check that the carabiners are in the proper configuration by opening both gates at the same time; in profile, the gates should appear to cross, forming an X.

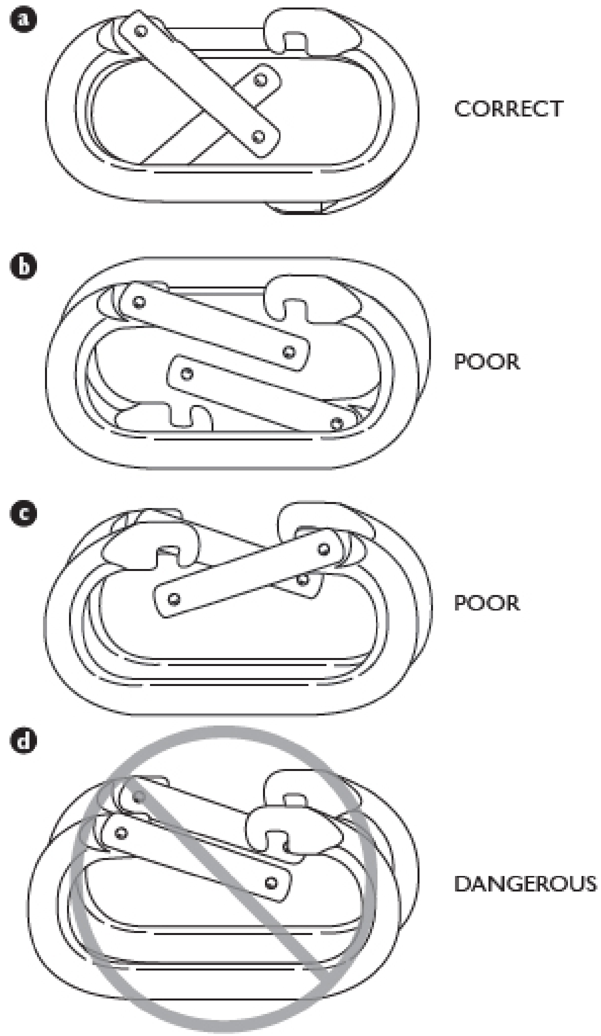

Fig. 9-37. Substituting double oval carabiners for a locking carabiner: a, gates are on opposite sides and the same ends, so they are opposite and opposed (correct); b, gates are on opposite sides and ends, so they are opposite and parallel (poor); c, gates are on same sides and opposite ends, so they are parallel and opposed (poor); d, gates are on the same sides and ends, so they are doubly parallel (dangerous).

USE AND CARE

A few basic rules apply to the use and care of all carabiners. Always make sure the force on a carabiner falls along the long axis and closer to the spine side; be especially careful that the gate does not receive the load. For example, see Figure 14-9 on clipping technique in Chapter 14, Leading on Rock.

Check the carabiner gates occasionally. A gate should open easily, even when the carabiner is loaded, and the gate should have good side-to-side rigidity when open.

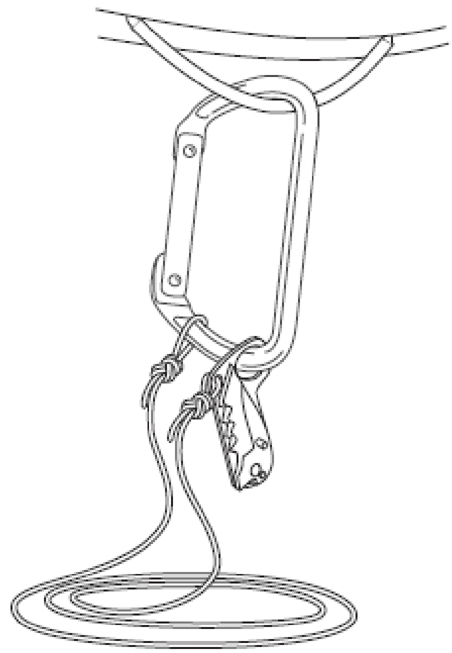

Fig. 9-38. Knife attached to carabiner with a lanyard.

A dirty gate can be cleaned by applying a solvent or lubricant (lightweight oil, citrus solvent, or products such as WD-40) to the hinge, working the hinge until it operates smoothly again, and then dipping the carabiner in boiling water for about 20 seconds to remove the cleaning agent.

Also, avoid bringing carabiners into contact with corrosive chemicals, especially acids, and avoid storing metals in damp and acidic environments.

KNIFE

A knife is an essential climbing tool that should always be kept within easy reach. It should be attached to the harness with a carabiner, and secured with an arm's length lanyard to avoid dropping it when unclipped for use (fig. 9-38). A knife could prove invaluable if an item becomes caught in the rappel device, for example. Always use caution when wielding a knife to avoid nicking the rope, especially when the rope is weighted. Ropes under tension can be easily nicked or worse.

KEEPING THE SAFETY NET STRONG

Ropes, harnesses, runners, and carabiners, as well as protection pieces (see Chapter 13, Rock Protection) and belay devices (see Chapter 10, Belaying), are all vital links in your chain of protection. Knowing your equipment and knowing how to use it is essential for safe climbing. But the most important part of the basic safety system is you. Your safety net, and the common sense, judgment, and awareness to use it properly, will keep you safe in a climbing environment.