EQUIPMENT • BASIC TECHNIQUES OF SNOW CLIMBING • ROPED SNOW CLIMBING TECHNIQUES • ROUTEFINDING ON SNOW • SAFE SNOW TRAVEL • GAINING FREEDOM OF THE SNOWY HILLS

CHAPTER 16

SNOW TRAVEL AND CLIMBING

Climbing in snow is fundamental to mountaineering. Snow is magical stuff, cloaking the landscape in a sparkling mantle. Gently falling snowflakes can be a balm to the human spirit, an aesthetic delight. But technically, snow is rather dryly defined as "a consolidated mass of water crystals." It is the degree of consolidation that is significant to the climber.

Snow falls in a variety of forms ranging from tiny crystals to coarse pellets. Initially the snowpack can consist of up to 90 percent air by volume. Once the snow is on the ground, a cyclic process of melting and freezing begins. Even though a snow climber might be literally walking on air, climbing on snow is not to be taken lightly. Snow becomes increasingly dense as the air is displaced, and ultimately, it will become a glacier. The density of glacial ice can be the same as that of ice formed directly from water. See Chapter 27, The Cycle of Snow, for more about snow.

Snow displays a broad spectrum of physical characteristics, and the distinction between hard snow and ice is rather arbitrary. Snow climbing is described in this chapter, whereas ice climbing techniques are discussed in

Chapters 19, Alpine Ice Climbing, and 20, Waterfall Ice and Mixed Climbing, but note that the techniques overlap with no distinct separation.

Climbers travel in a world that is affected by snow on two very different scales. On a rather grand scale, snow—in the form of glaciers—sculpts the terrain. On a more human scale, snow often is the climbers' landscape, largely determining how and where they can travel.

Traveling on snow is trickier than hiking a trail or climbing a rock wall. A rock face is essentially unchanging, whereas the snowpack undergoes rapid changes. Depending on the degree of consolidation, snow can present a widely variable surface: seemingly insubstantial and bottomless unconsolidated powder, a consistently firm and resilient snow surface, or rock-hard alpine ice. A snowpack that appears to be firm can under certain conditions suddenly collapse and flow (avalanche) and then quickly set up as hard as concrete. Safe snow travel requires judgment based on experience.

During a single season, a snowfield may start as a dusting of snow over a brushy slope, progress to a bowlful of powder ready to avalanche, then change to a solid surface offering firm footing, and finally revert back to scattered snow patches. In the course of a day, snow can change from a firm surface in the morning to slush in the afternoon.

Snow can facilitate travel, making climbs easier by providing a pathway over brush and other obstacles on the approach hike and reducing the danger of loose rock on the ascent. But snow conditions also affect decisions on routefinding and climbing technique. Should the climbing party hike up the more easily traversed, snow-covered valley slopes or on the ridge crest away from avalanche hazard? Should climbers go for easy step-kicking up the sunny slope or the more labor-intensive climb on the firmer, more stable snow of the shaded hillside? Is it safer to travel roped or unroped? The changeable nature of snow requires climbers to be flexible in choosing their mode of travel and to be ready to use snowshoes, skis, or crampons.

EQUIPMENT

Ice axes and crampons are at the top of the list of basic snow climbing equipment. Snowshoes, skis, ski poles, and shovels are other important snow travel aids. Climbers must also sometimes construct anchors in snow (snow protection equipment is discussed in "Snow Anchors" later in this chapter).

ICE AXE

The ice axe, or *piolet*, and skill in its use allow climbers to venture onto all forms of snow and ice, enjoying a greater variety of mountain terrain during all seasons of the year. Selecting an ice axe means choosing between features designed for specific uses. A long axe is suitable for cross-country travel and scrambling, in which it is used as a cane and to provide security in low-angle climbing. However, on steeper slopes, a shorter axe is better. Axes designed for ice climbing (typically called ice tools) have even shorter shafts and specialized features including the shape of pick and adze and the placement of teeth. (Ice tools are discussed in Chapter 19, Alpine Ice Climbing.)

Weight is another consideration. The adage "light is right" should not be taken too far. Be sure to select an axe that is designed for the intended use. Some very light axes are meant for only light use—that is, ski mountaineering or trekking. Ice axes that meet the European Committee on Standardization (CEN) standards for general mountaineering (see Chapter 9, Basic Safety System) are designated by a "B," generally tamped on the ice axe. At the other extreme, technical ice axes tend to be heavier (and more expensive) than general mountaineering axes. Tools that meet the CEN standards for technical mountaineering are designated by a "T." Ice axes designated with a "T" rating meet higher strength requirements than "B"-rated axes.

Parts of the Ice Axe

The main parts of an ice axe include: the head, pick, adze, shaft, and spike.

Head. The head of an ice axe—the pick and the adze (fig. 16-1)—is typically made of steel alloy or aluminum. The hole in the axe head, the carabiner hole, is used by most climbers to attach the ice-axe leash.

Pick. The pick is curved or drooped (fig. 16-2a), a design that provides better hooking action in snow or ice, enabling the axe to dig in when climbers are seeking purchase or trying to stop themselves (self-arrest) after a fall. A moderate hooking angle of 65 to 70 degrees relative to the shaft is typical of general mountaineering axes (fig. 16-2b). A sharper angle of 55 to 60 degrees is better for technical ice climbing (fig. 16-2c); the more acutely angled pick holds better in ice and snow and it coincides with the arc of the tool head as it is swung.

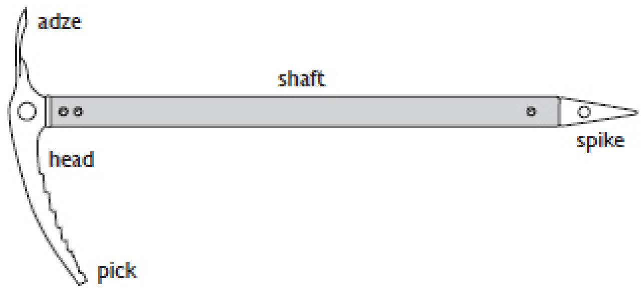

Fig. 16-1. Parts of an ice axe.

The pick teeth provide grip in ice and hard snow. Ice axes designed for general mountaineering typically have aggressive teeth only at the end of the pick, as shown in Figure 16-2a and b. Picks of ice axes and tools designed for technical climbing typically have aggressive teeth along the entire length, as shown in Figure 16-2c.

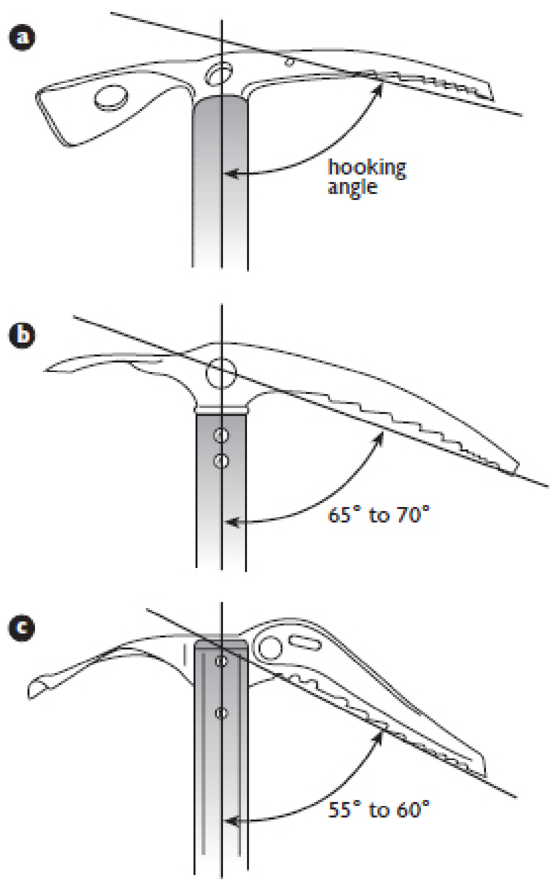

Fig. 16-2. Ice-axe pick shapes and teeth patterns: a and b, for general mountaineering; c, for technical ice climbing.

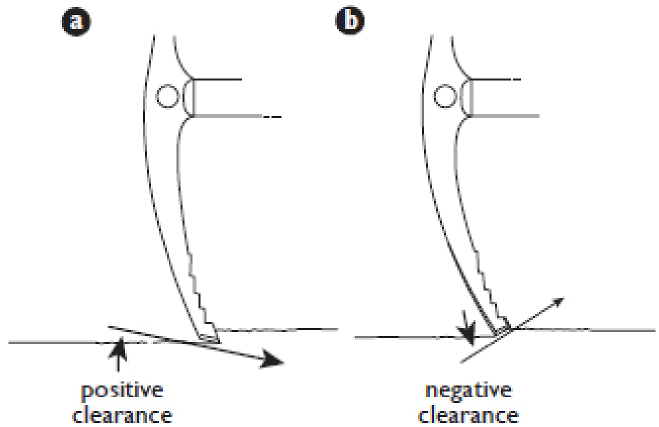

Fig. 16-3. Ice-axe clearance: a, positive; b, negative.

The end of the pick may have clearance that is termed positive (fig. 16-3a), neutral, or negative (fig. 16-3b). The clearance is determined by comparing the angle of the pick tip relative to the axis of the shaft; positive clearance means the pick tip's angle is greater than 90 degrees relative to the shaft, and negative clearance means the pick tip's angle is less than 90 degrees relative to the shaft. In theory, the degree of clearance affects how the axe performs in self-arrest. A pick with positive clearance should penetrate more readily; a pick with negative clearance would tend to skate across and lose purchase on ice or hard snow. However, the clearance actually makes little difference: self-arrest is almost impossible on ice, and in softer snow the pick will dig in regardless of what type of clearance it has. Positive clearance is important for technical use in ice climbing. (Ice tools are discussed in Chapter 19, Alpine Ice Climbing.)

Adze. The adze is used mainly to cut steps in hard snow or ice. The flat top of the adze also provides a firm, comfortable platform for a hand when the climber is using the self-belay grasp (see "Basic Techniques of Snow Climbing" later in this chapter). Most adzes for general mountaineering are relatively flat and straight-edged with sharp corners (see Figure 16-2a). This is the best all-around design for cutting steps.

Shaft. Ice-axe shafts (see Figure 16-1) are made of aluminum or a composite material such as fiberglass, Kevlar, or carbon fiber—or a combination of these. A typical ice-axe shaft for general mountaineering is straight. Ice axes with a shaped shaft are designed for more technical use such as swinging the ice axe for ice climbing.

Some shafts are covered at least partly by a rubber material, which gives climbers a better grip and, hence, better control of the axe, and it also dampens vibrations and increases a climber's control in planting the pick. If the axe shaft lacks a rubber grip, wrap the shaft with athletic grip tape (for example, bicycle handlebar tape) or wear gloves with leather or rubberized palms. However, the friction of any shaft covering may impede the axe from readily penetrating the snow when it is being used for a boot-axe belay, for probing, or for self-belay.

Spike. The spike—the metal tip of the axe (see Figure 16-1)—should be sharp enough to readily penetrate snow and ice. Using the ice axe for balance on rocky trails and talus slopes dulls the spike (see "Ice-Axe Maintenance and Safety" below).

Ice-Axe Length

Ice axes are described only in metric units; they range in length from 40 to 90 centimeters (16 to 35 inches). The shortest axes are for technical ice climbing; the longest ones are for tall mountaineers using the axe as a cane on easy terrain.

The optimal length for an ice axe depends upon both the intended use and the height of the climber. A common rule of thumb is for an ice-axe spike to barely reach the ground when you hold the head loosely at your side. This length offers the best compromise of balance and appropriate length for use on steep snow slopes. For climbers who are mostly traveling across glaciers and lower angle snow, a longer axe will give a nice length for balance and safety. For climbers who are on steeper snow, a shorter axe, with a spike that reaches the ankle when the axe is loosely held at your side, may be easier to place for balance and protection.

Axes shorter than 50 centimeters are technical ice climbing tools, excellent for placements on very steep slopes. However, these ice tools are not as good for self-arrest; the shorter shafts offer less leverage, and many of the technical pick designs do not lend themselves to the self-arrest technique. A 70-centimeter axe is the longest that is generally useful for technical ice climbing. Thus, a length of 50 to 70 centimeters works well in most alpine situations, wherein climbing is on moderately steep snow slopes and the axe is being used for self-belay and self-arrest. Longer axes are better for cross-country travel and scrambling, for snow anchors, and for probing for cornices and crevasses.

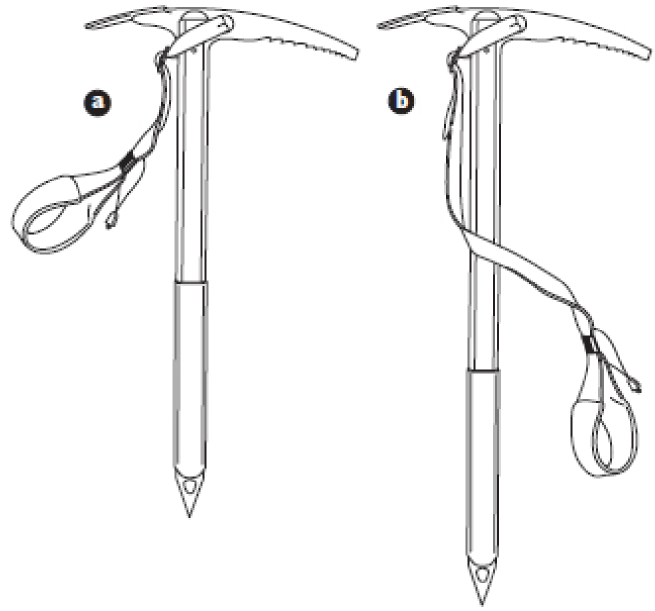

Fig. 16-4. Ice-axe leashes, attached through hole in head of axe: a, short; b, long.

Ice-Axe Leash

The ice-axe leash provides a sure way to attach the ice axe to the climber's wrist or harness. A leash is valuable insurance on crevassed glaciers or long, steep slopes where losing an axe would leave a climber without a principal safety tool and put climbers below in danger from the run-away axe. A leash also allows climbers to let the ice axe hang free while they make a move or two on the occasional rock they encounter during a snow climb.

There are two schools of thought regarding the use of an ice-axe leash during snow travel that requires using self-belay technique. Most climbers use a leash to keep from losing the ice axe. Others, however, believe that a flailing ice axe, hanging by the leash from the wrist of a climber who is no longer gripping the shaft, poses danger during a fall. Ultimately, choosing whether to use a leash is a personal judgment call.

The leash typically consists of a piece of accessory cord or webbing attached to the carabiner hole in the ice-axe head. A vast array of commercially manufactured leashes are available, or a leash can be made using either 5- or 6-millimeter Perlon accessory cord or ½- to l-inch tubular webbing. Tie the ends of the material together with a suitable knot to create a sling, girth-hitch the sling through the carabiner hole, then tie an overhand knot to form a wrist loop.

The length of a leash can vary. Short leashes (fig. 16-4a) are favored by those using ice axes for basic snow and glacier travel. The short leash is easy to use and allows climbers to regain control of the ice axe quickly during a fall. During an uncontrolled fall in which a climber loses the grip on the ice axe, an axe on a short leash will not flail around as much as one on a longer leash.

However, the majority of climbers prefer a longer leash (fig. 16-4b). When shifting the axe from one hand to the other while changing direction up a snow slope, a climber with a long leash does not need to switch the leash from wrist to wrist. A long leash can be chained to a runner clipped to the harness, so that the axe can be used as a personal anchor. The long leash also makes the axe more versatile for climbing steep snow or ice. A long leash is usually about as long as the axe shaft, and if it is adjusted correctly, it will reduce arm fatigue during step-cutting and ice climbing. The climber should be able to grasp the end of the shaft near the spike when that hand is placed through the wrist loop.

Ice-Axe Maintenance and Safety

Ice axes require very little special care. Before each use, inspect the shaft for deep dents that might weaken it to the point of failure under load (but do not worry about minor nicks and scratches). After each climb, clean mud and dirt off the axe. Use a combination of solvents (such as a lubricating and penetrating oil) and abrasives (scouring pads or a soft ski hone—a soft synthetic block with embedded abrasive) to remove any rust.

Check the pick, adze, and spike regularly for sharpness. To sharpen, use a hand file, not a power-driven grinding wheel. High-speed grinding can overheat the metal and change the temper, diminishing the strength of the metal.

Guards are available to cover the sharp edges and points of the pick, adze, and spike if the ice axe is not in use. Some people leave the guards on when carrying the ice axe on their pack. (See also “How to Carry an Ice Axe,” later in this chapter.) For storage following a climb, dry the ice axe and store without the guards on to protect the pick from rusting.

CRAMPONS

Crampons are a set of metal spikes that strap on over boots to penetrate hard snow and ice where boot soles cannot gain sufficient traction (see the

"History of Crampons" sidebar). Crampons are useful for both ascending and descending steep snow and ice. The choice to wear crampons depends upon a variety of factors, including snow conditions and the confidence and experience of the climber.

HISTORY OF CRAMPONS

Crampons are an ancient tool, invented more than 2,000 years ago. Early inhabitants of the Caucasus region wore leather sandals soled with spiked iron plates to travel on snow and ice. Celtic miners used iron foot spikes as early as 2,700 years ago. Medieval alpine shepherds wore three-point crampons—horseshoe-shaped frames bearing three sharp spikes.

At the end of the 19th century, the four-point crampon was state of the art. Then in 1908 Oscar Eckenstein created the 10-point crampon. Many alpinists thought the gadgets were an unsporting advantage. However, these crampons relieved climbers of the tremendous tedium of cutting steps and opened up a vast array of unclimbed snow and ice faces. In 1932 Laurent Grivel added two front points, creating the 12-point crampon, which was specifically designed for climbing steep hard snow and ice. This design has evolved into the crampons that are essential for mountaineering today.

In harder, icy conditions where a dangerous fall is possible, crampons are likely a good choice. For an inexperienced climber on softer snow with a steep angle, crampons can provide an additional sense of confidence to complete the climb. Make this decision based on individual skill and experience, as well as personal assessment of conditions as described below in "Basic Techniques of Snow Climbing." Choosing among the different crampon designs involves a trade-off between features that are essential for general alpine use and those designed for technical ice climbing (see the "Questions to Consider When Selecting Crampons" sidebar).

Crampon Points

The early-model 10-point crampon was eclipsed in the 1930s by the 12-point crampon, with two forward-slanting or "front" points, which reduced the need for step-cutting and permitted front-pointing up steep snow and ice (see

Chapter 19, Alpine Ice Climbing). Currently, crampons designed for general mountaineering include both 12-point and lighter 10-point models, but all have front points.

Most crampons are made from chromium molybdenum steel, an extremely strong, lightweight alloy. However, some models are fabricated from aircraft-grade aluminum alloys, which are about 50 percent lighter than steel but also much softer. Aluminum crampons are mainly used for glacier travel or early-season climbs with snow but not hard ice. Snow and ice routes often include short sections of rock that are climbed wearing crampons. Most crampons are able to take the punishment, but extended travel on rock will dull the points.

The relative angles and orientation of the first two rows of points determine the best use for a set of crampons. When the first row (front points) is drooped and the second row (secondary points) is angled toward the front of the crampon (fig. 16-5a), the crampons are better suited for ice climbing than for general mountaineering. This configuration allows easier engagement of the secondary points when front-pointing, which greatly reduces calf strain (see Chapter 19, Alpine Ice Climbing). In contrast, downward-angled secondary points (fig. 16-5b) facilitate a more ergonomic walking motion on moderate terrain.

Front points can be either horizontally (the point is wide side to side but thin, fig. 16-5c) or vertically (the point is narrow side to side but "tall" top to bottom, fig. 16-5d) oriented. Vertically oriented front points, with height that is greater than their width, are designed for technical ice climbing. Their shape mimics that of an ice-axe pick. They are well suited for penetration into hard water ice, but in softer alpine ice and snow, they are prone to shearing through unless they are deeply set. In contrast, horizontally oriented front points, with width that is greater than their height, are designed for the alpine ice and snow conditions encountered in most general mountaineering situations. They provide a larger surface area and, therefore, are more stable in softer snow.

Hinged and Semirigid Crampons

Mountaineering crampons are generally categorized into two types—hinged and semirigid—based on the connection between the forward and rear units.

QUESTIONS TO CONSIDER WHEN SELECTING CRAMPONS

When shopping for crampons, ask the following questions:

- What type of crampon is appropriate for your intended activity?
- What terrain is the crampon designed for?
- How will you know when the crampons fit your boots?
- Which attachment system is best for your needs?

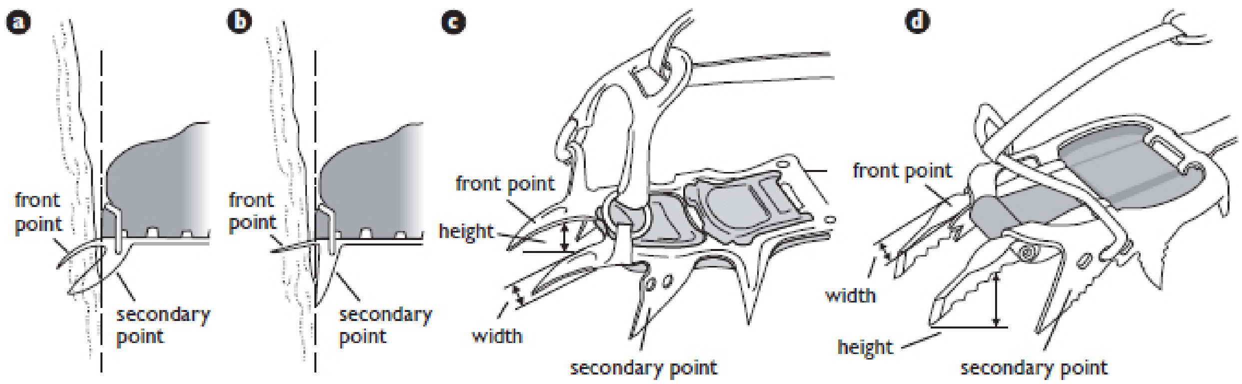

Fig. 16-5. Angle of first two rows of points: a, out from toe of boot suited for front-pointing; b, downward-angled secondary points best suited for general mountaineering; c, horizontal front points best suited for general mountaineering; d, vertical front points best suited for technical ice climbing.

Hinged. Crampons designed for general mountaineering can be hinged (fig. 16-6a), with forward and rear units connected by a flexible bar. They fit a wide variety of mountaineering boots, are light, and flex with the natural rocking action of walking. Hinged crampons work well on low-angle snowfields and glaciers.

Semirigid. Crampons designed for both general mountaineering and technical ice climbing (fig. 16-6b) have forward and rear units connected by a more rigid bar. They have some flex, which creates some give with a fairly stiff-soled boot. Semirigid crampons are designed with either horizontally or vertically oriented front points. This type of crampon works well on a variety of alpine snow and ice routes.

Crampon Attachment

There are three main crampon attachment systems: strap, clip-on, and hybrid. In general, hinged crampons work best with strap systems and flexible boots. Semirigid crampons work best with hybrid attachment systems—a combination of a rear clip and straps over the front of the boot—and fairly stiff boots. Ultimately, the choice of crampon attachment system is largely dictated by the attachment platform that the boot provides as well as the intended use.

Straps. Modern strap, or universal, bindings (fig. 16-7a) are much easier and faster to use than earlier strap systems. If climbers plan to do a wide variety of climbing and scrambling over a range of terrain (trail, rock, and snow), this binding type will provide secure and fast attachment with the widest selection of footwear. These are excellent bindings for use with a mountaineering boot covered by an insulating overboot.

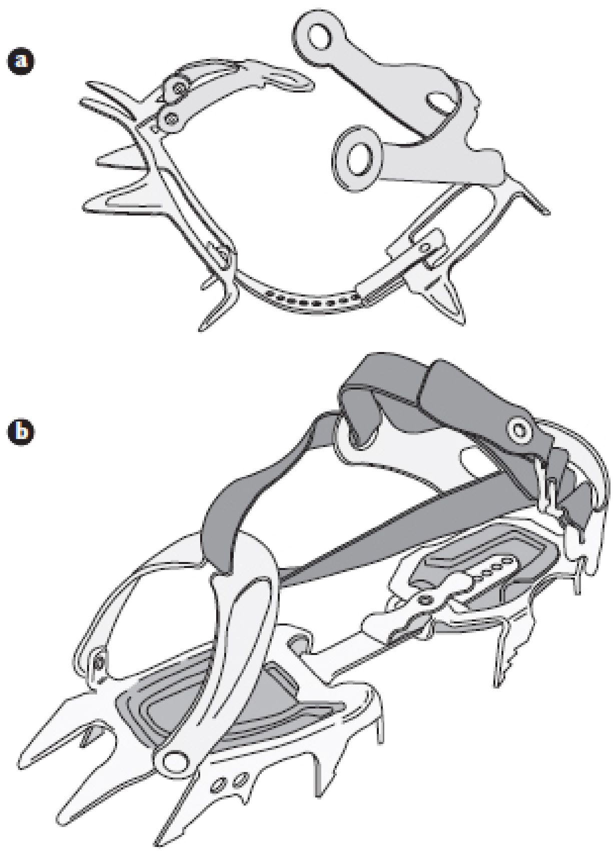

Fig. 16-6. Types of crampons: a, hinged; b, semirigid.

Clip-ons. With clip-on bindings, the crampons attach to the boot with a wire toe bail and a heel clip or lever (fig. 16-7b). These systems are fast and easy to use. With clip-on bindings, the fit of the crampon to the boot is much more critical than with crampons that strap on. In order to fit securely, the boot must have pronounced grooves at both the heel and toe. When the crampon is sized correctly, the heel clip should decisively "snap" into place, forcing the wire toe bail firmly into the boot toe groove. Clip-on bindings typically include a safety strap wrapped around the ankle to secure the crampon if it pops off the boot. Some clip-on bindings also include a metal strap attached to the toe bail; the ankle safety strap is threaded through the metal toe-bail strap to prevent the crampon from popping off the boot.

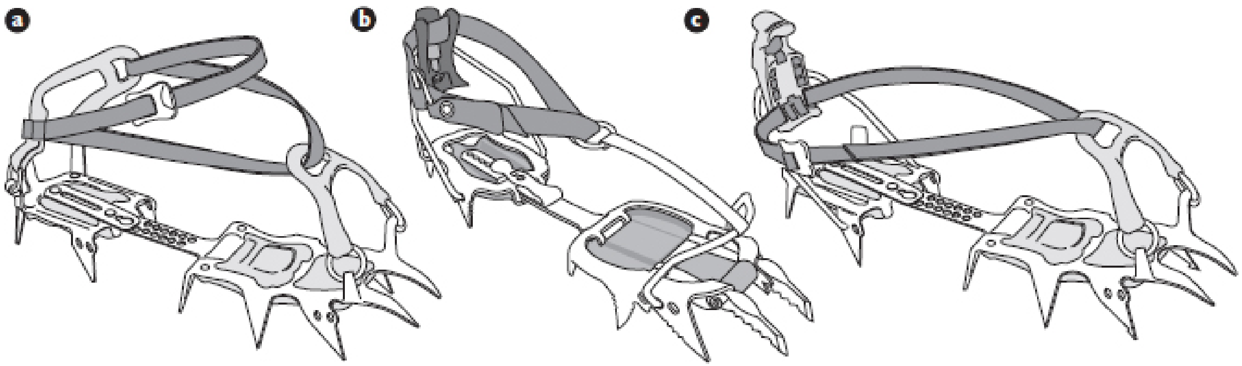

Fig. 16-7. Systems for attaching crampons to boots: a, strap or universal; b, clip-on; c, hybrid.

Hybrid. Hybrid bindings feature toe straps combined with a heel clip (fig. 16-7c). These bindings are popular because they work well on boots that have a pronounced heel groove but may lack a toe groove. As with clip-on bindings, the hybrid's heel clip should decisively "snap" into place, forcing the boot into the front posts attached to the toe strap. Hybrid bindings also include a safety strap connecting the heel bail to the toe strap.

TIPS FOR FITTING CRAMPONS

- Clip-on bindings grip the boot at toe and heel, so the boot's welt is especially important. Clip-on bindings require well-defined grooves at the toe and heel on plastic and very stiff leather boots.
- The front crampon points should protrude 3?4 to 1 inch (2 to 2.5 centimeters) beyond the toe of the boot.
- Crampons must be fitted to overboots or expedition gaiters if either will be worn to help insulate feet from the cold and snow in very cold conditions. Make sure any attachment straps are long enough.

Crampon Fit

It is critical that crampons fit boots perfectly. When purchasing crampons, bring the boots to the shop for a proper crampon fitting (see the "Tips for Fitting Crampons" sidebar). If the crampons will be used on more than one pair of boots, check the fit on all pairs. Be sure to purchase crampons that match the intended usage.

Practice putting on the crampons while in the comfort of home. There will be plenty of opportunity to put them on under less-ideal conditions: by feel in dim light or in the limited illumination of a headlamp, fumbling with cold, numbed fingers.

Crampon Maintenance and Safety

Regular simple maintenance keeps crampons safe and dependable (see the "Crampon Safety Rules" sidebar). After every climb, clean and dry the crampons and inspect them for wear. Repair or replace worn straps, nuts, bolts, and screws. Check the points: For ice climbing, maintaining sharp points is essential, but for most snow climbing and classic mountaineering, it is best not to have sharp points. New crampons frequently come with razor-sharp points (fig. 16-8a) and will almost always require a bit of maintenance or tuning before use (fig. 16-8b); file down burrs, rough edges, and very sharp points with a small file. If crampon points are overly dull, a file can also be used to sharpen them. Also check alignment of the points: splayed points make the crampons less efficient at penetrating snow and ice and more likely to slash pants, gaiters, and legs. It is probably best to retire a pair of crampons when points have been badly bent or overly filed.

In soft, sticky snow, crampons can accumulate a growing buildup of snow. This ball of snow can interfere with the crampon points' penetration and be dangerous, particularly where sticky snow overlays an icy base. To minimize this hazard, climbers can use manufactured antiballing plates: plastic, rubber, or vinyl sheets that can be slid into rubber-fitted metal stays on the bottom of the disassembled crampon (fig. 16-9). Alternatively, climbers can wrap the bottom of the crampon with duct tape. When soft, sticky snow is encountered, consider whether crampons are really needed. It may be safer to proceed without them.

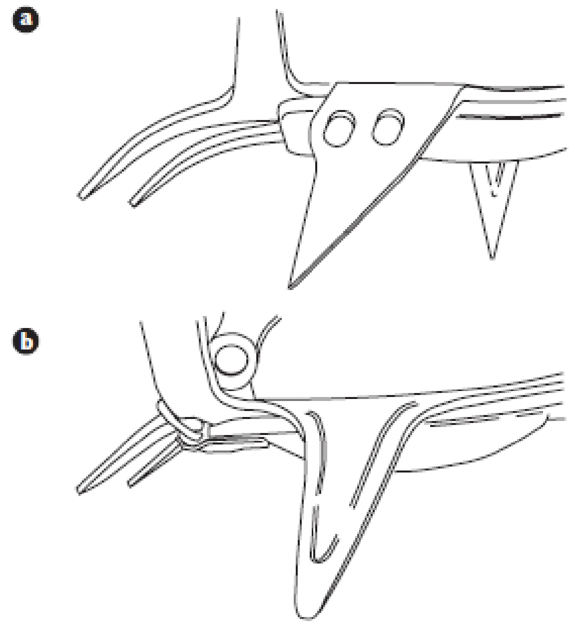

Fig. 16-8. How to finish crampon points: a, very sharp (new); b, rounded off (after filing).

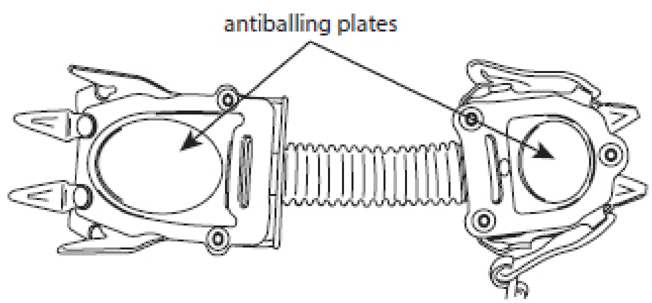

Fig. 16-9. Crampons with antiballing plates.

Instep and Approach Crampons

Small instep crampons with four or six points are designed for crossing an occasional short snowfield. Because these crampons have no points at the heel or toe, they are not suitable for mountaineering and can be dangerous on steep snow or ice. Approach crampons are flexible, full-length plates that typically have eight points. Approach crampons are designed for use on moderate terrain, and they also are not suitable for mountaineering. Instep and approach crampons are not a substitute for 10- or 12-point mountaineering crampons.

CRAMPON SAFETY RULES

In the mountains, climbers can follow a few rules to protect themselves, their gear, and their climbing companions from sharp crampon points:

- Use a crampon pouch or a set of rubber point protectors when carrying crampons.
- Always bring the tools needed to adjust the crampons, as well as any necessary spare parts.
- While climbing with crampons on, step deliberately to avoid snagging pants or gaiters, gashing a leg, or stepping on the rope.
- Be careful not to snag gear that is hanging low from gear loops on the climbing harness; avoid letting slings hang below the thigh.

SKI POLES

Ski poles are used not only for skiing; ski or trekking poles can be used whether climbers are traveling on foot, snowshoes, or skis. Poles are better than an ice axe for balance when climbers are carrying heavy packs over level or low-angle snow, slippery ground, or scree or when they are crossing a stream or boulder field. Poles also can take some of the weight off the lower body, and the basket at the bottom of the poles keeps them from penetrating too deeply into soft snow.

Some ski and trekking poles have features helpful to the mountaineer. Adjustable poles enable climbers to set the length to suit the conditions or the terrain; on a traverse, the uphill pole can be set to a length shorter than the downhill pole. These poles can be fully compressed for easy packing. Adjustable poles require more maintenance; after each trip, disassemble, clean, and dry them.

Poles with removable baskets can serve as probes for crevasses when their baskets are removed. Some poles are made so that a pair can be fastened together to form a serviceable avalanche probe. However, they are a poor substitute for a commercial avalanche probe.

Some ski poles can be fitted with a special self-arrest grip that has a plastic or metal-tipped pick, but on technical terrain this option is *not* a substitute for an ice axe.

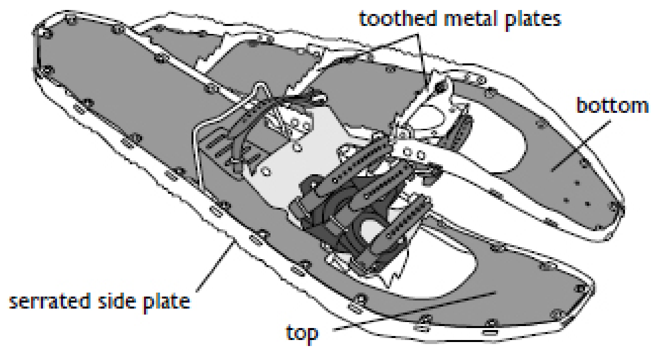

Fig. 16-10. Snowshoes for winter mountaineering.

SNOWSHOES

Snowshoes, a traditional aid for snow travel, have been updated recently to be smaller and lighter. Modern designs include models consisting of tubular metal frames with lightweight, durable decking materials (fig. 16-10), as well as plastic-composite models. Modern bindings are easy to use and more stable than older models. Snowshoes include crampon-like, toothed metal plates designed to improve traction on hard snow; many models also include serrated heel and/or side plates that decrease side-to-side slippage.

Snowshoes permit efficient travel in soft snow, where hikers otherwise laboriously posthole, sinking deeply with each step. Snowshoes can be used to kick steps uphill. Although travel on snowshoes may be slower than travel on skis, snowshoes can be used in brushy or rocky terrain where skis would be awkward, and snowshoes are often more practical than skis when climbers are carrying heavy packs. If the climbing party includes some people who are not very good on skis, it is much less frustrating and more efficient for the group to travel on snowshoes. Snowshoe bindings can be used with almost any footwear, whereas most ski bindings require specialized boots.

SKIS

Mountaineering skis fitted with climbing skins provide a convenient mode of travel in the mountains. The two styles of mountaineering skiing, telemark and alpine touring (AT or randonée), require specialized boots (some bindings can accommodate mountaineering boots, but there is a significant loss of skiing performance). Telemark and AT or randonée bindings allow the skier's boot heel to hinge upward for easy uphill touring as if cross-country skiing. But whereas the traditional telemark ski binding (fig. 16-11a) has a "free heel” for telemark turns down the slope, the randonée or AT binding locks the boot down for parallel turns and standard downhill technique (fig. 16-11b).

The past two decades have seen a marked evolution and rapid development of both AT and telemark ski gear for ski mountaineering in terms of weight, shape, and size. In fact, skis used for AT and telemark are now often the same make and model, differing only in the types of bindings used. Both modern types of skis are quite wide compared to the older alpine gear. And both modern types are highly shaped, often with modified tips and tails for ease and stability of turning during the descent. Telemark and randonée skis permit climbers to travel the backcountry through the use of climbing skins attached temporarily to ski bottoms to provide traction for uphill travel (fig. 16-11c). Climbing skins, originally made of seal fur and now of a napped synthetic material, allow skis to slide forward over snow while gripping and holding the skis from sliding backward.

Climbers who are not accomplished skiers may find that the disadvantages of using skis in the backcountry outweigh the advantages. When the skis must be carried, they can be awkward in some terrain—catching on rocks and trees—and add weight to a pack already laden with technical gear. Wearing skis complicates self-arrest, and skiing can be difficult when climbers are carrying heavy packs. Every party member must have similar skiing ability for the group to keep a steady pace. This is especially true for roped glacier travel.

Skis can be faster for basic snow travel, and they can provide a way to reach areas that are otherwise inaccessible. Skis offer a bonus for glacier travel: they distribute the climber’s weight over a larger area and may decrease the chance of breaking through snow bridges. Skis can also come in handy for rescue work, because they can be converted into a makeshift stretcher or sled.

Backcountry skiing is a complex activity, utilizing special techniques and equipment. For detailed information, see Resources.

SHOVEL

A broad-bladed shovel is both a tool and a safety device for the snow traveler. A shovel is a necessity for uncovering an avalanche victim. Shovels are also used for constructing snow shelters and tent platforms, and they have even been used as climbing tools to ascend particularly snowy routes.

A good shovel (see Figure 3-11a, b, and c in Chapter 3, Camping, Food, and Water) has a blade large enough to move snow efficiently and a handle long enough for good leverage but short enough for use in a confined area: 2 to 3 feet (60 to 90 centimeters) long. Some shovels have extendable and/or detachable handles. Another desirable feature is a blade that can be rotated perpendicular to the handle and locked so that the shovel can be used as a trenching tool. A D-shaped grip on the handle can make shoveling more comfortable. Some models have a hollow handle, inside which climbers can carry a snow saw or avalanche probe.

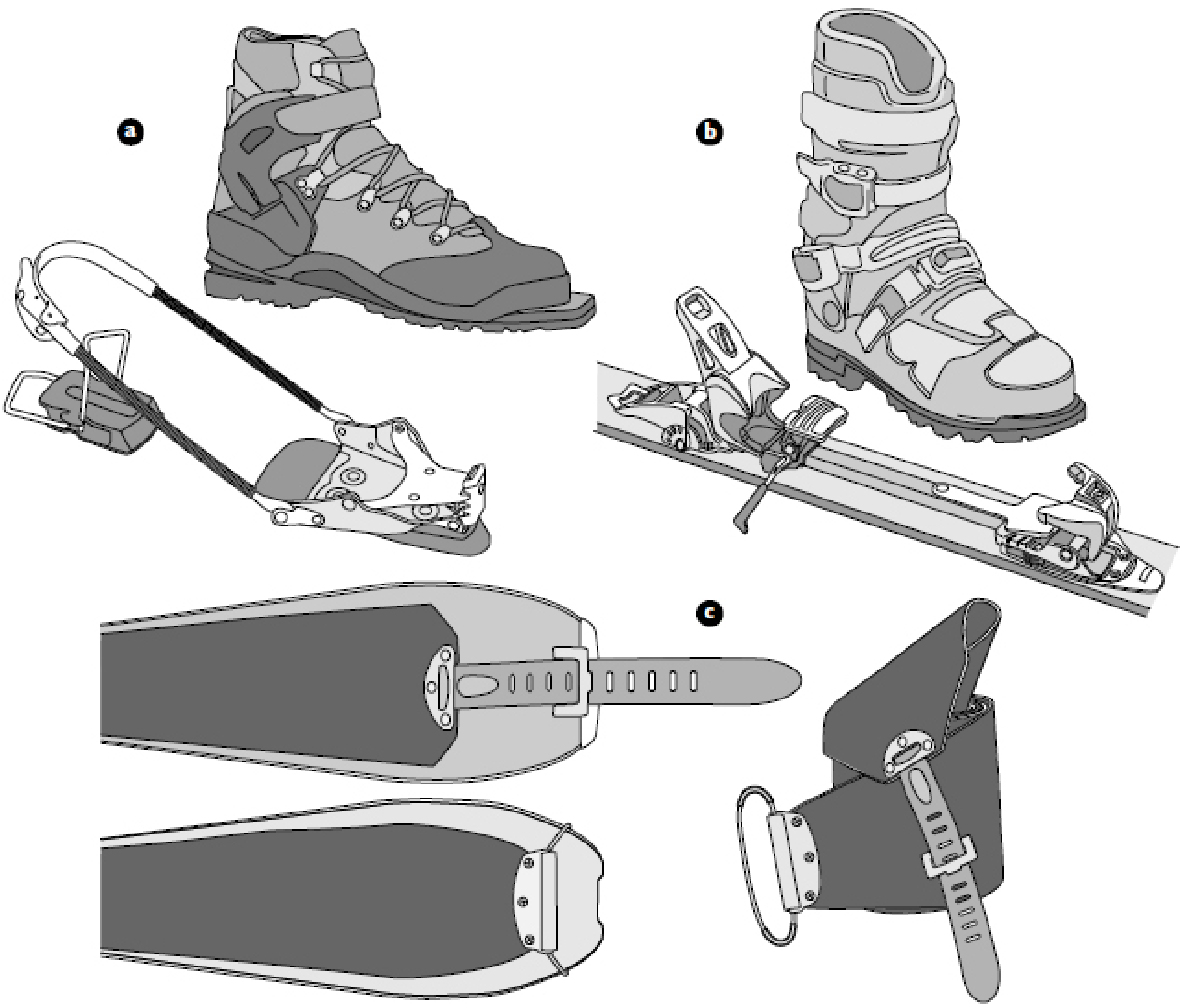

Fig. 16-11. Ski equipment for mountaineering: a, traditional telemark boot and binding; b, randonée or alpine touring (AT) boot and binding; c, climbing skins for skis.

In dry, powdery snow, a plastic-bladed shovel provides a good compromise of weight to strength. However, metalbladed shovels are much stiffer and therefore better for chopping through hard snow or avalanche debris. The edge of a shovel blade (whether metal or plastic) can be sharpened with a file for better cutting of hard snow. Shovels are also used in various snow stability tests (see Chapter 17, Avalanche Safety).

BASIC TECHNIQUES OF SNOW CLIMBING

The first priority of snow travel is to avoid a slip or fall, but if climbers do slip on snow, they must know how to regain control as quickly as possible. Travel on steep alpine snow slopes is dangerous unless climbers have an ice axe and crampons—and the skill to use them.

To determine the route, terrain, and equipment choices for traveling on steep alpine snow safely, ask the following questions: Is the snow good for self-belay, or is it too hard for the ice-axe shaft to be placed securely? If someone were to fall, what does the runout look like? Will crampons be helpful or a hindrance? What are the climbers' levels of experience and skill? Is everyone comfortable with the particular situation? Are climbers wearing heavy overnight packs?

Relying on self-belay or self-arrest (see "Stopping a Fall" later in this section) should be considered adequate only for very experienced climbers. Understanding the limits of self-belay and self-arrest, combined with assessing the runout, are crucial considerations.

ASSESSING RUNOUT

Because a falling climber's acceleration rate on a 30-degree snow slope can approach that of free-falling, it is important to always be aware of a snow slope's runout. Are there rocks, crevasses, a moat, a bergschrund, or cliffs below you (fig. 16-12)? Constantly assessing and being aware of runout is the first thing to consider when deciding what techniques and equipment to use for travel on snow slopes.

Fig. 16-12. Assessing runout: rocks below a snow slope make for a dangerous runout.

If the runout is dangerous or unknown, always carefully consider how to proceed. Is a belay with anchor and rope required? If a belay is deemed necessary and there is not time, skill, or equipment for a solid belay, the climbing party will probably be safer turning around.

USING THE ICE AXE

The ice axe, an inherently simple tool, has many uses. Below the snow line, it can serve as a walking cane or be used to help climbers brake when they are going downhill. But its main role is in snow and ice travel, wherein it is a balance aid, a tool to prevent a fall, and a tool to stop a fall. The ice axe is also used in a variety of ways to make a snow anchor.

How to Carry an Ice Axe

Always carry an ice axe carefully. Be aware of what its sharp points and edges can do to you and others in the climbing party.

When the axe is not needed, carry it on your pack. Slip it down through the pack ice-axe loop, flip the shaft up, and strap it to the pack (fig. 16-13a). Keep guards on the pick, adze, and spike. To carry the axe in one hand, grasp the shaft with the spike forward and the pick down to avoid jabbing the person behind you (fig. 16-13b).

When travel on snow alternates briefly with areas of rocks or steep brush, where both hands need to be free, slide the axe diagonally between your back and the pack (fig. 16-13c). Place the spike down and the pick between the pack's two shoulder straps, so the axe head is clear of your neck and pointing in the same general direction as the angle of the shaft. In this position, the axe can be stowed and retrieved quickly.

How to Grasp an Ice Axe

There are two ways to grasp an ice axe. Conditions determine which grasp is best at any moment.

Self-arrest grasp. Place your thumb under the adze and your palm and fingers over the pick, near the top of the shaft (fig. 16-14a). While climbing, point the adze forward. The self-arrest grasp puts climbers in position to go directly into arrest in case of a fall (see "Self-Arrest" later in this section).

Self-belay grasp. Rest your palm on top of the adze and wrap your thumb and index finger under the pick (fig. 16-14b). While climbing, point the pick forward. The self-belay grasp can be more comfortable and is appropriate when the consequences of an unchecked slide are not a concern (see "Self-Belay" later in this section).

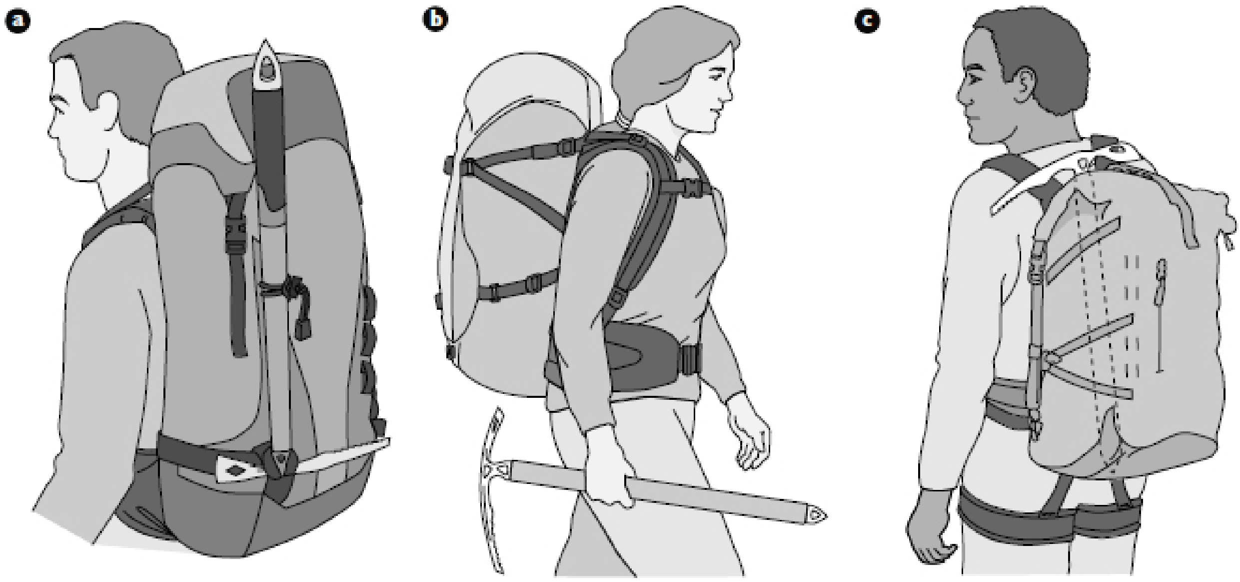

Fig. 16-13. Carrying an ice axe, when not in use: a, attached to pack by ice-axe loop and straps; b, in hand while walking, with spike forward and pick down; c, temporarily between back and pack.

It is generally easier to start out holding the axe in the self-arrest grasp when practicing with an ice axe. Most climbers simply choose to use the self-arrest grasp at all times. Some prefer the comfort of the self-belay grasp but shift to the self-arrest grasp whenever they feel the runout is a concern or there is a significant danger of slipping.

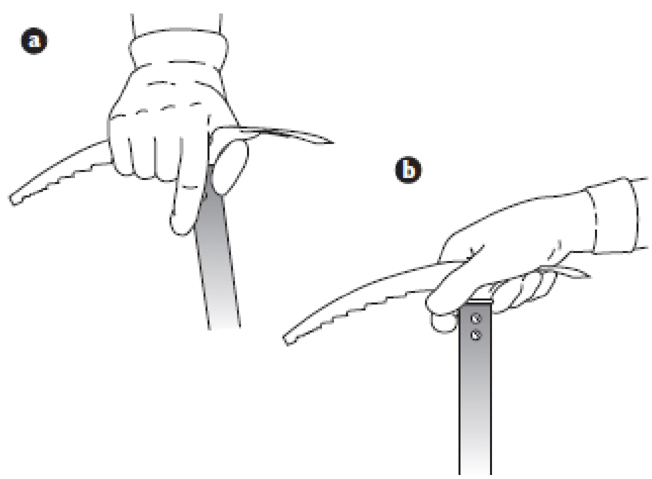

Fig. 16-14. Grasping an ice axe: a, self-arrest grasp; b, self-belay grasp.

USING CRAMPONS

Crampons are generally considered essential when conditions are icy, but they can also be useful on snow, even soft snow. For ice, a bit of crampon technique is usually necessary (see “Climbing with Crampons” in Chapter 19, Alpine Ice Climbing). For snow, simply use the same techniques you would without crampons: step-kicking, combined with balance and use of an ice axe (all described in this section); the crampon points will improve traction and security.

Learn how and when to use crampons. Ask these questions: Are crampons helpful? Do they make walking on snow easier and more efficient? Does the slope have a dangerous or unknown runout? (If yes, then crampons should always be considered.) What footwear is being worn? (Rigid-soled boots kick steps much better than softer, more flexible boots; crampons should be considered more often with softer, more flexible footwear because many crampon designs will add stiffness to the boots.)

One reason for not wearing crampons is the increased potential for tripping in them or even being injured by their sharp points. Learning to walk in crampons without tripping takes practice, and injury from sharp points can be reduced with proper crampon maintenance (see “Crampon Maintenance and Safety” above).

Another reason not to use crampons is if snow is balling up underfoot. Snow can stick to the underside of the metal crampon frame, packing into a ball that interferes with the effectiveness of the crampon points. Fresh snow combined with warm temperatures can create conditions that even antiballing plates cannot overcome. Such conditions can be particularly challenging. Sometimes the snow may be hard under the softer fresh snow, requiring crampon use even when the snow sticks to them. These conditions with or without crampons require great care, and they will certainly slow progress. If the decision is made to wear crampons, then knocking the stuck snow free with an ice axe may be necessary, sometimes with every step.

ASCENDING SNOW

Climbing up snow slopes takes a set of special skills. Different techniques come into play, depending on the slope’s hardness or steepness. The direction of ascent can be either direct or diagonal.

Climbing in Balance

Although climbers need to be proficient at ice-axe self-arrest, this skill is a last resort and every effort should be made to avoid arresting. Climb in balance to avoid falling. Climbing in balance means moving from one position of balance to another, avoiding any prolonged stance in an out-of-balance position.

On a diagonal uphill route, a climber is in a position of balance when the inside (uphill side) foot is in front of and above the outside (downhill side) foot, because body weight is evenly distributed between both feet (see Figure 16-15a). When the outside foot is forward, the climber is out of balance because the trailing inside leg, which is not fully extended and therefore cannot make use of the skeletal structure to minimize muscular effort, is nonetheless bearing most of the body's weight (see Figure 16-15b).

The diagonal ascent is a two-step sequence: from a position of balance through an out-of-balance position and back to a position of balance. From the position of balance, place the axe above and ahead of you into the snow in the self-belay position (fig. 16-15a). Move up one step, bringing your outside (downhill) foot in front of your inside (uphill) foot, which puts you out of balance (fig. 16-15b). Then move up another step, putting your inside foot in front of your outside foot, which puts you back in a position of balance (fig. 16-15c). Then reposition the ice axe. Keep your weight over your feet and avoid leaning into the slope. Keep the axe on your uphill side.

If a climber is heading straight up the fall line, there is no longer an uphill or downhill reference for positioning arms and legs. Just carry the axe in whichever hand feels comfortable, and climb in a steady, controlled manner. Regardless of the direction of travel, firmly place the axe before each move to provide self-belay protection.

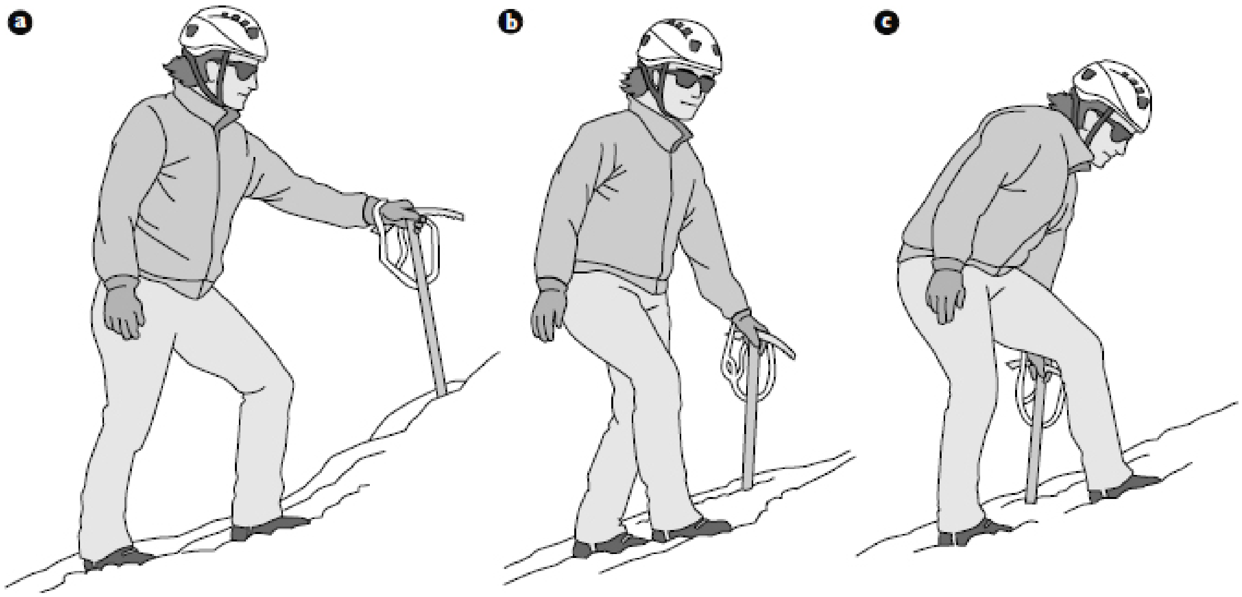

Fig. 16-15. Ascending a snow slope, diagonally, in balance: a, placing the ice axe from a position of balance; b, advancing one step into an out-of-balance position; c, advancing another step back into a position of balance.

Using the Rest Step

Climbing a long, featureless snow slope can give a frustrating sensation of getting nowhere. Few landmarks help measure progress. Novice climbers try a dash-and-gasp pace in an attempt to rush the objective. But the only way to the top of the slope is to find a pace that can be maintained—and then maintain it. The solution is the rest step, a technique that conserves energy as it moves the climber methodically forward. Use the rest step whenever legs or lungs need a bit of recuperation between steps. At lower elevations, it is usually leg muscles that require a break; at higher elevations, lungs need the pause. See “The Rest Step” in Chapter 6, Wilderness Travel.

Step-Kicking

Step-kicking creates a path of upward steps with the best possible footing and the least expenditure of energy. Climbers move in single file up the steps, improving them as they go. The head of the line has the hardest job: kicking fresh steps and looking for the safest route up the slope.

The most efficient kick to use for creating snow steps is to swing your leg and allow its own weight and momentum to provide the impact, with little muscular effort. This works well in soft snow. Harder snow requires more effort, and the steps may be smaller and less secure.

An average climber needs steps deep enough to place the ball of the foot when going straight up and at least half of the boot on a diagonal ascent. Steps that are kicked level or tilted slightly into the slope are more secure. The less space there is on a step, the more important it is that the step be angled into the slope.

When kicking steps, keep other climbers in the party in mind. They can follow up your staircase if the steps are spaced evenly and somewhat close together. Make allowance for climbers with shorter legs.

Followers improve the steps as they climb. The follower must kick into the step, because simply walking onto the existing platform is not secure. In compact snow, drive your toe in and deepen the step. In soft snow, bring your boot down onto the step, compacting the snow and making the step stronger.

Switch leads occasionally to share the heavy work. The leader can step aside and fall in at the end of the line. (The related skills of step-cutting and cramponing are discussed in Chapter 19, Alpine Ice Climbing.)

Fig. 16-16. Direct ascent with ice axe in cane position.

Fig. 16-17. Direct ascent with ice axe in stake position.

Making a Direct Ascent

Speed is a consideration on a long snow climb, and a direct ascent is a good choice if climbers face bad weather, avalanche or rockfall danger, poor bivouac conditions, or a difficult descent. Ice-axe technique varies according to snow conditions and steepness.

Cane position. On a slope of a low or moderate angle, climb with the axe in the cane position: holding it in one hand by the head and using it for balance (fig. 16-16). Continue in the cane position as the snow gets steeper, as long as it feels secure. Setting the axe firmly before each move provides a self-belay.

Stake position. As the snow gets steeper, climbers may choose to switch to the two-handed stake position (fig. 16-17). Before moving upward, use both hands to plant the axe as far as it will go into the snow. Then continue to grasp it with both hands on the head or with one hand on the head and one on the shaft. This position is useful on steeper soft snow.

Horizontal position. On steep, hard snow covered with a soft layer, climb with the axe in the horizontal position. Hold the axe with both hands, one in the self-arrest grasp on the head and the other near the spike end of the shaft. Jab the axe horizontally into the snow above you, the pick down and the shaft at a right angle to your body (fig. 16-18). This jabs the pick into the harder base while the shaft gets some purchase in the softer surface snow.

Fig. 16-18. Direct ascent with ice axe in horizontal position.

Making a Diagonal Ascent

When time and weather conditions permit, climbers may prefer a longer diagonal ascent, switchbacking up moderately angled slopes. In marginal conditions, a diagonal route may be more difficult because of the work of kicking numerous edged, traversing steps in hard snow. Again, ice-axe technique varies according to snow conditions and steepness.

Cane position. The axe works fine in the cane position on moderate slopes (see Figure 16-16). As the slope gets steeper, this position becomes awkward.

Cross-body position. Hold the axe perpendicular to the angle of the slope, one hand grasping the head and the other holding the spike end of the shaft, and jab the spike into the snow (fig. 16-19). The axe crosses diagonally in front of you, the pick pointing away from your body. The shaft should bear your weight, while the hand on the head of the axe stabilizes the axe.

Fig. 16-19. Diagonal ascent with ice axe in cross-body position.

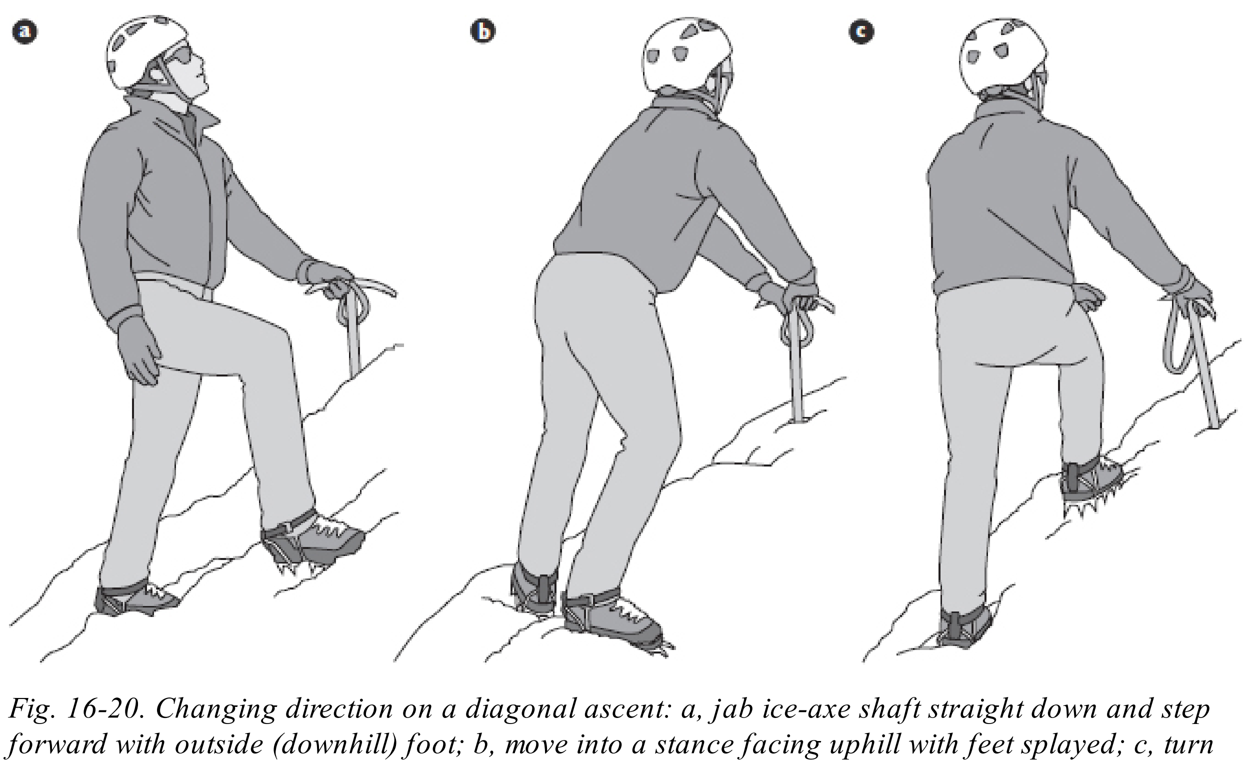

Fig. 16-20. Changing direction on a diagonal ascent: a, jab ice-axe shaft straight down and step forward with outside (downhill) foot; b, move into a stance facing uphill with feet splayed; c, turn in new direction of travel and step forward with new inside (uphill) foot.

Changing directions. Diagonal ascents often mean changing direction, or switchbacking. The sequence of steps to change direction safely on a diagonal route, whether the axe is in the cane position or the cross-body position, is this:

1. Start from a position of balance, with your inside (uphill) foot in front of and above your outside (downhill) foot. Jab the axe shaft straight down into the snow at a spot directly above your location.
2. Move your outside (downhill) foot forward, bringing you into an out-of-balance position (fig. 16-20a).
3. Grasp the head of the axe with both hands. Continue holding onto the head with both hands while moving into a stance facing uphill, turning your inside foot toward the new direction of travel and ending with your feet in a splayed position (fig. 16-20b). Kick steps into the slope if your splayed feet feel unstable.
4. Turn your body toward the new direction of travel, returning to a position of balance by placing your new uphill foot in front of and above your new outside (downhill) foot (fig. 16-20c).

In the cane position, your new uphill hand now grasps the axe head (as in Figure 16-20c). In the cross-body position, the hands holding the head and the shaft are now reversed.

Traversing

Long horizontal traverses that neither gain nor lose elevation are best avoided. This "sidehill gouging" is fine on soft snow at low and moderate angles, although it is not as comfortable or as efficient as a diagonal route. If it is necessary to traverse over hard or steep snow, face directly into the slope and kick straight into it for the most secure steps.

DESCENDING SNOW

One mark of a skillful snow climber is the ability to go downhill efficiently and confidently. Descending snow is frequently more challenging than ascending the same slope. Due to gravity and momentum, it is easier to slip while descending than while ascending. Many otherwise competent and aggressive climbers blanch at the prospect of going forward down a steep, exposed snow gully. To move down, place the axe down low, which provides a less-comfortable stance and handhold than on the way up. Master the following descent techniques to help conquer any uneasiness about downhill travel.

Facing Out (Plunge-Stepping)

When descending, determine technique mainly by the same factors as when ascending: the hardness and angle of the snow. In soft snow on a moderate slope, simply face outward and walk down. With harder snow or a steeper angle, use the plunge step.

The plunge step is a confident, aggressive move. Face outward, step assertively away from the slope, and land solidly on your heel with your straightened leg vertical, transferring weight solidly to the new position (fig. 16-21a). Avoid leaning back into the slope, which can result in less secure steps or perhaps an unplanned glissade. Keep knees slightly bent, not locked, and lean forward to maintain balance. How much the knees are bent depends on the angle of the slope (the steeper the slope, the greater the bend) and the firmness of the surface (the harder the snow, the greater the bend). Plunge-stepping can be secure with steps that hold only the heel of the boot, but most climbers do not trust steps shallower than that.

When plunge-stepping, maintain a steady rhythm, almost like marching. This helps maintain balance. Once a comfortable rhythm is found, do not stop. Plunge-stepping in a stop-and-start fashion can cause climbers to lose their balance.

When plunge-stepping, hold the ice axe in one hand in either the self-arrest or self-belay grasp, with the spike close to the surface of the snow, well forward and ready to be planted in the snow (see Figure 16-21a). Spread out your other arm and move it for balance. Some climbers hold the axe in both hands in the full self-arrest position—one hand on the head, the other near the end of the shaft—but this allows less arm movement for maintaining balance.

An aggressive stride creates a deep step. Take care in deep, soft snow not to plunge so deeply that your legs get stuck and you fall forward, injuring yourself. If the snow is too hard or steep for plunge-stepping, descend in a crouched position, planting the axe as low as possible in a self-belay with each step (fig. 16-21b). Typically it is easier to plunge-step by picking your own line rather than following others’ footsteps down.

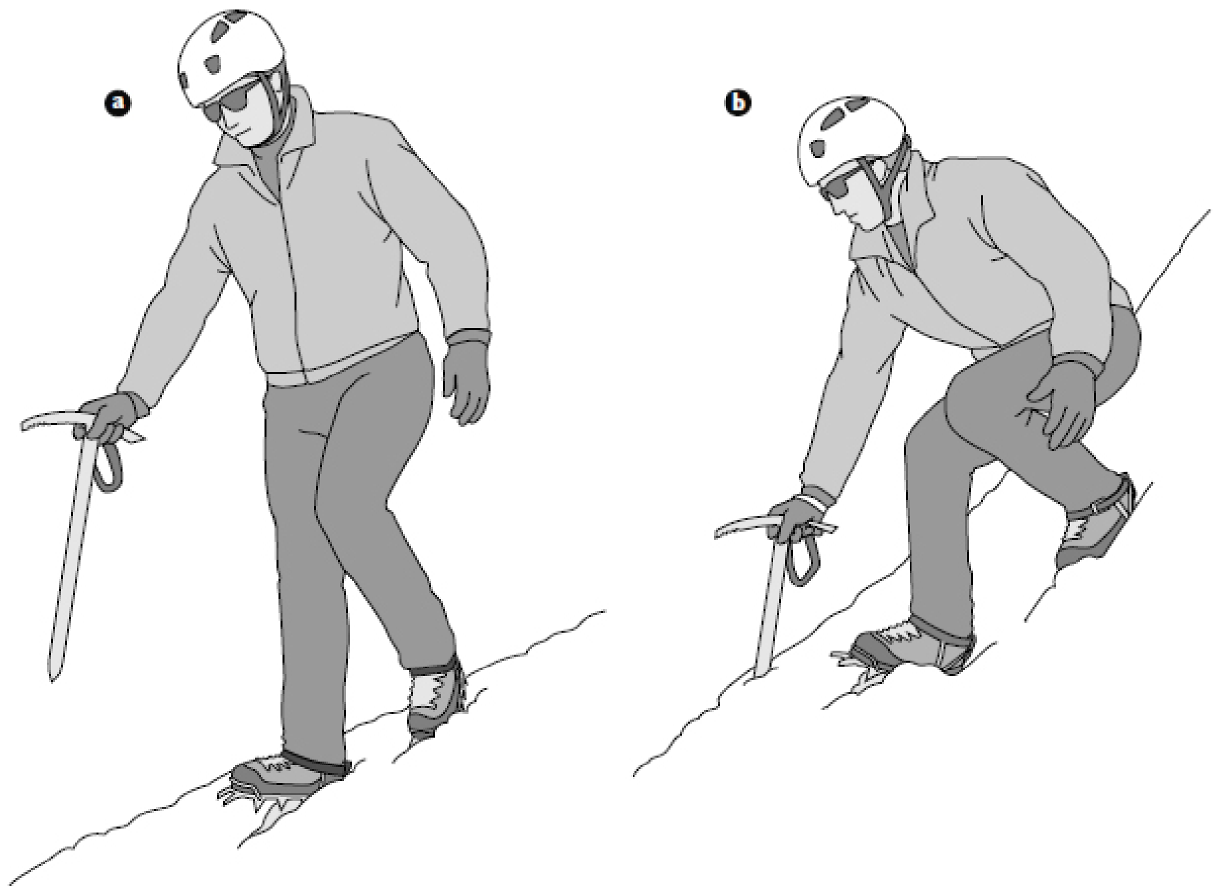

Fig. 16-21. Facing out (plunge-stepping): a, on moderate slope; b, with self-belay on steeper slope.

Facing In (Backing Down)

While generally slower than facing out, backing down is usually more comfortable and secure. Try to plunge the shaft of the ice axe as low on the slope as is comfortable before stepping down (fig. 16-22). If the snow is too firm for a solid shaft placement, the pick of the axe (placed low) can be used for support while the climber steps down. Remember that leaning into the slope does not put your body in a good position of balance. Try to keep your weight centered over your feet as much as possible.

Fig. 16-22. Facing in (backing down): place axe low on the slope and don't lean in toward the slope.

Glissading

Glissading is the fastest, easiest, and most exhilarating way down many snow slopes if climbers are on foot. On slopes where speed can be controlled, it is an efficient alternative to walking or plunge-stepping.

Glissading can be hazardous. Do not glissade in crevassed terrain. Glissade only when a safe runout is close enough that if a slide goes out of control, the climber will not be injured before reaching it. Unless the climbing party can see the entire descent route, the first person down must use extreme caution and stop frequently to look ahead. The biggest risk is losing control at such a high speed that self-arrest is impossible. This is most likely to happen on the best glissading slope: one with firm snow.

Before glissading, remove crampons and stow them and other hardware inside the pack; crampon points can catch in the snow and send climbers tumbling. Wear waterproof breathable hardshell pants to keep dry (see Chapter 2, Clothing and Equipment). Wear gloves to protect hands from the abrasive snow.

Always maintain control of the ice axe. If an ice-axe leash is worn, climbers risk injury from a flailing axe if it is knocked loose from their grip. If a leash is not used, climbers risk losing their axe.

Effective glissading requires a smooth blend of several techniques. Climbers who lack finesse in the standing glissade (see below) often use a combination: breaking into a plunge step to control speed, stepping off in a new direction rather than making a ski-style turn, and skating to maintain momentum as the slope angle lessens.

Sometimes in soft snow, a glissader accidentally sets off a mass of surface snow, which slides down the slope with the glissader aboard. These are small avalanches, known as “avalanche cushions.” The trick is to decide whether the avalanche cushion is safe to ride or is about to become a serious avalanche. If the moving snow is more than a few inches deep, self-arrest will not work because the ice-axe pick cannot penetrate to the stable layer below. Sometimes climbers can drive the spike deep enough to slow the glissade, although probably not deep enough to stop themselves. Unless you are sure the cushion is safe and the glissade speed is under control, get off. Roll sideways out of the path of the moving snow and then self-arrest.

Of the three methods of glissading—the sitting glissade, the standing glissade, and the crouching glissade—the one to use depends on snow and slope conditions, the appearance of the runout, and the climber’s mastery of the techniques.

Sitting glissade. On soft snow on which climbers would bog down if they tried a standing glissade, the sitting glissade works. Sit erect in the snow, bend the knees, and plant boot soles flat along the snow surface (fig. 16-23a). Hold the ice axe in self-arrest position while glissading downhill. To maintain control, run the spike of the axe like a rudder along the snow on one side of you. Keep both hands on the axe. Put pressure on the spike to reduce speed and to thwart any tendency of the ice-axe head to pivot downward.

Fig. 16-23. Glissade positions: a, sitting; b, standing; c, crouching.

The standard posture, with knees bent and feet flat, also reduces speed. This posture is good when the snow is crusted or firmly consolidated, pitted with icy ruts or small suncups (hollows melted by the sun), or dotted with rocks or shrubs. It provides more stability and control than having legs straight out in front and helps minimize wear and tear on a climber's bottom.

To stop, use the spike to slow down, then dig in your heels—but not at high speed, or a somersault may be the result. For an emergency stop, roll over and self-arrest.

Turns are almost impossible to make in a sitting glissade. The best way to get around an obstruction is to stop, walk sideways to a point that is not directly above the obstacle, and glissade again.

Standing glissade. The most maneuverable technique is the standing glissade, and it saves clothes from getting wet and abraded. This glissade is similar to downhill skiing. Crouch slightly over your feet, bend the knees, and spread out your arms (fig. 16-23b). Feet, which provide stability, can be spread out or placed together, with one foot slightly forward to improve stability and prevent nosedives. Bring the feet closer together and lean forward over them to increase speed.

To slow down and stop, stand up and dig in your heels, turn feet sideways and dig their edges into the slope, or crouch and drag the ice-axe spike as in the crouching glissade (see below).

It is also possible to perform a turn similar to skiing by rotating your shoulders, upper body, and knees in the direction you want to turn and rolling your knees and ankles in the same direction to rock your feet onto boot edges.

The standing glissade is most effective on a firm base with a softer layer on top. The softer the snow, the steeper the slope needs to be to maintain speed. It is possible to do a standing glissade down slopes of harder snow, but these are usually slopes of lower angles with a safe runout. It is possible to skate slopes of very low angles if the snow is firm.

Responding to changes in the snow texture is tricky. If you hit softer, slower snow, your head and torso will suddenly outpace your legs, so move one boot forward for stability. If you hit harder, faster snow or ice below the surface, lean well forward to prevent a slip. Keep the glissade speed under control by regularly braking and traversing.

Crouching glissade. The crouching glissade is slower than a standing glissade and easier to learn. From the standing glissade position, simply lean back, hold the ice axe in the self-arrest position to one side of your body, and drag the spike in the snow (fig. 16-23c). Because it uses three points of contact, the crouching glissade is also more stable. However, turning and controlling speed when crouching are more difficult.

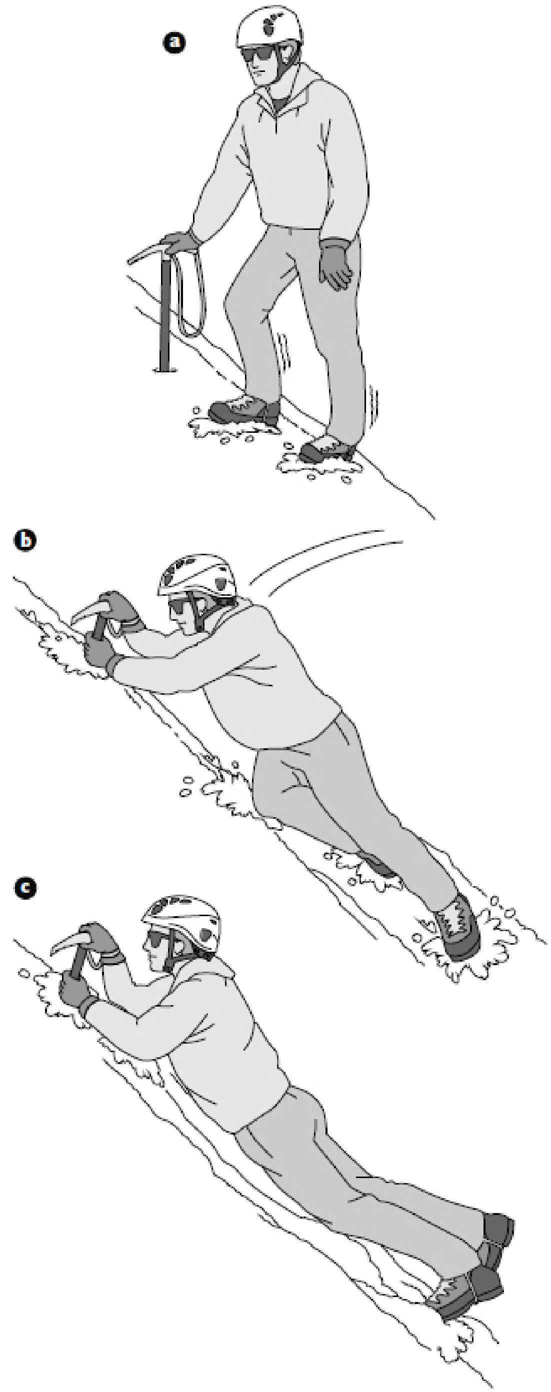

Fig. 16-24. The self-belay: a, climbing; b, falling; c, recovering.

STOPPING A FALL

To prevent a fall, climbers need to know how to self-belay, and to stop a fall, they must be prepared to self-arrest. Always wear gloves on snow slopes;

snow is quite abrasive, and sliding unprotected over its surface can cause hands to lose their grip on the ice axe.

Self-Belay

Self-belay can keep a simple slip or misstep on a snow slope from turning into a serious fall. To self-belay, be sure both feet are secure, then jam the spike and shaft of the ice axe straight down into the snow (fig. 16-24a). Continue to grip the head of the axe with your uphill hand while moving forward. (Use either the self-belay grasp or the self-arrest grasp to perform self-belay.) Take a step or two, pull out the axe, and replant it. For self-belay to work, the shaft must be placed deep enough in firm snow to hold your full weight.

If you slip, keep one hand on the head of the axe and grab the shaft at the surface of the snow with your other hand (fig. 16-24b). The key to successful self-belay is to grab the shaft right next to the surface, so that you pull against the buried shaft. Your hand on the head of the axe minimizes the risk of levering the axe out (fig. 16-24c).

If self-belay fails and you begin an uncontrolled slide down the slope, you must immediately self-arrest.

Self-Arrest

Preventing a fall is a primary goal while climbing, but if climbers do fall, their life may depend on self-arrest skills and stopping the fall as quickly as possible. Self-arrest technique holds a climber's fall or the fall of a rope mate. During glacier travel, self-arrest stops the rest of the team from sliding into a crevasse (discussed in Chapter 18, Glacier Travel and Crevasse Rescue). For climbers who master self-arrest, steep snow slopes become highways to the summit.

The primary goal of self-arrest is to stop a fall, ideally in a safe, secure, and stable position. Figures 16-25c, 16-27e, and 16-28d illustrate the completion of a successful self-arrest: lying facedown in the snow with the ice axe beneath you. Here is how to do it:

- **Hold the axe in a solid grip.** Place one hand in the self-arrest grasp, with your thumb under the adze and fingers over the pick (see Figure 16-14a), and your other hand on the shaft just above the spike.

- **Press the pick into the snow above your shoulder.** Place the adze near the angle formed by your neck and shoulder. This is crucial. Sufficient force cannot be exerted on the pick if the adze is not in the proper position.
- **Place the shaft across your chest diagonally.** Hold the spike end close to the hip that is opposite the axe head. Grip the shaft near the spike end to prevent that hand from acting as a pivot point around which the spike can swing to jab your thigh. (A short axe is held the same way, although the spike will not reach the opposite hip.)
- **Press your chest and shoulder down on the ice-axe shaft.** Successful self-arrest relies on your body weight falling and pressing on the axe, rather than arm strength alone driving the axe into the snow.
- **Keep your head facedown.** Place the brim of your helmet in contact with the slope. This position prevents your shoulders and chest from lifting up and keeps weight over the adze.
- **Place your face in the snow.** Your nose should be touching the snow.
- **Arch your spine slightly away from the snow.** This places the bulk of your weight on the axe head and on your toes or knees, which are the points that dig into the snow to force a stop. Pull up on the spike end of the shaft, which starts the arch and rolls your weight toward your shoulder by the axe head.
- **Bend your knees slightly.** Place them against the surface to slow the fall in soft snow. On harder surfaces, where knees have little stopping power, they help stabilize your body position.
- **Keep your legs stiff and spread apart, toes digging in.** If wearing crampons, dig in with knees and keep toes off the snow. If it's a life-or-death situation, dig in with whatever you can.

Self-arrest technique depends on the position the climber is in after a fall. A fallen climber will be sliding in one of four positions: head uphill or head downhill and, in either case, facedown or on the back.

If a climber is falling, the immediate goal is to get the body into the only effective self-arrest position: head uphill, feet downhill, and face pressed into the snow. The first move toward that goal is to grasp the axe with both hands, one hand on the axe head in the self-arrest grasp and the other hand at the base of the shaft. The next moves depend on what position the climber is in while falling.

Head uphill, facedown. All the climber has to do is get the pick pressed into the snow and body over the axe shaft, ending in a secure self-arrest.

Head uphill, on your back. Falling with your head uphill, on your back (fig. 16-25a), is not much more difficult to self-arrest than falling with your head uphill, facedown. Roll toward the head of the axe and aggressively plant the pick into the snow at your side while rolling over onto your stomach (fig. 16-25b). Roll in the direction of the axe head (fig. 16-25c). When you fall (fig. 16-26a), beware of rolling toward the spike, which can jam the spike in the snow before the pick (fig. 16-26b) and wrench the axe from your hands (fig. 16-26c).

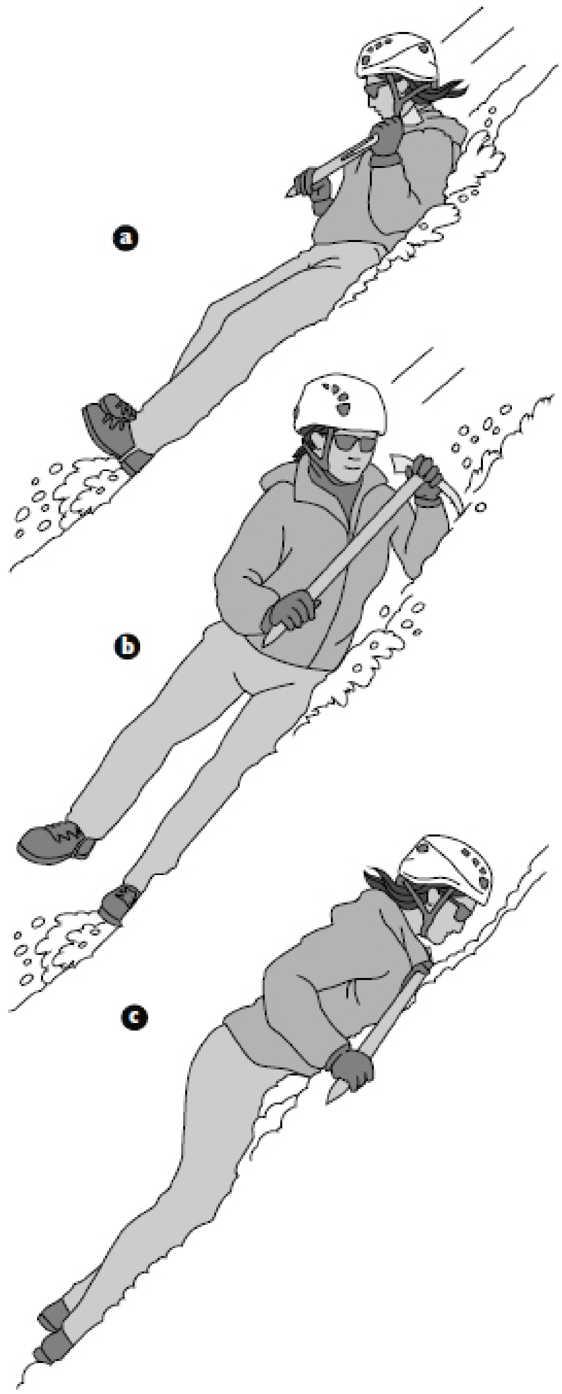

Fig. 16-25. Correct self-arrest technique, head uphill, on your back: a, falling; b, rolling onto your stomach; c, the completed self-arrest.

Fig. 16-26. Incorrect self-arrest technique, head uphill, on your back: a, falling; b, rolling toward spike; c, axe is wrenched out of your hands.

Head downhill, facedown. Self-arrest from a headfirst fall is more difficult because you must first swing your feet downhill. In this facedown predicament, reach downhill and off to the axe-head side (fig. 16-27a) and get the pick into the snow (fig. 16-27b) to serve as a pivot to swing your body around (fig. 16-27c). Work to swing your legs around (fig. 16-27d) so they are pointing downhill (fig. 16-27e). Never jab the spike into the snow and pivot on that end of the axe. That will bring the pick and adze of the axe across your slide path and on a collision course with your chest and face.

Head downhill, on your back. Again, self-arrest from a headfirst fall is more difficult because you must first swing your feet downhill. In this faceup predicament, hold the axe across your torso and aggressively jab the pick into the snow (fig. 16-28a), then twist and roll toward it (fig. 16-28b). Once again, the pick placed to the side serves as a pivot point. Planting the pick will not bring you around to the final self-arrest position. Work at rolling your chest toward the axe head (fig. 16-28c) while swinging your legs around to point downhill (fig. 16-28d). A sitting-up motion using body core strength helps the roll.

Practice self-arrest in all positions on increasingly steeper slopes and hard snow above a safe runout. Practice with a full pack. The key to success is to get quickly into the arrest position and dig in. During practice, leave the ice-axe leash off your wrist so there is less chance of the axe striking you if you lose control of it. Cover or pad the adze and spike to minimize chances of injury. Although crampons are often worn on snow slopes where self-arrest may be necessary, crampons should never be worn when practicing self-arrest.

The effectiveness of the self-arrest depends on the climber's reaction time, the steepness and length of the slope, and snow conditions.

On steep or slippery slopes. When the slope is too steep or slippery, even the best technique will not stop a slide. Acceleration on hard snow, on even a modest snow slope, can be so rapid that the first instant of the fall is the whole story: the climber rockets into the air and crashes back to the unyielding surface with stunning impact, losing uphill-downhill orientation.

On hard or loose snow. Arresting on hard snow is difficult, if not impossible, but always give it a try, even if on belay. In loose snow, the pick may not be able to reach compact snow, making the usual self-arrest useless. The best brakes in this case are feet and knees and elbows, widely spaced and deeply pressed into the snow. If the initial efforts at self-arrest are unsuccessful, do not give up. Keep fighting. Even if you do not stop, the attempt itself may slow the fall and help prevent rolling, tumbling, and bouncing. It may also help keep you sliding feetfirst, the best position if you end up hitting rocks or trees. If a falling climber is roped to other climbers, anything the falling climber can do to slow the fall increases the chance that self-arrests or belays will hold.

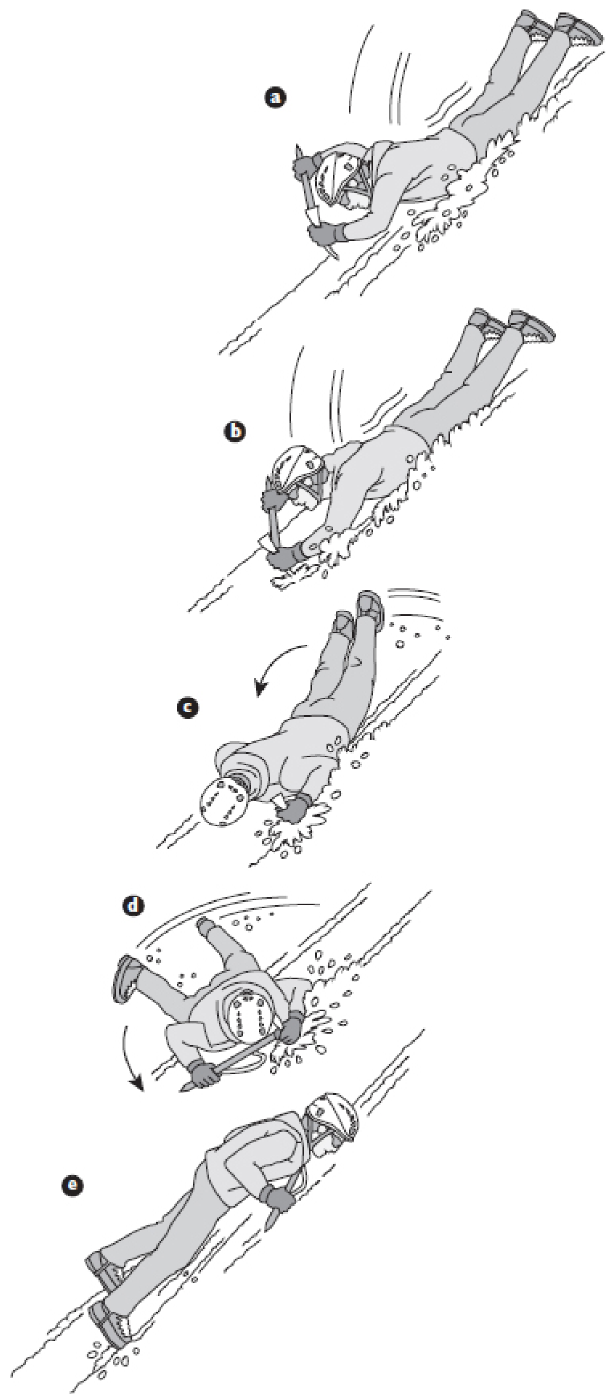

Fig. 16-27. Self-arrest technique, head downhill, facedown:
a, reach downhill and to the same side as the ice axe's head;
b, plant the pick into the snow;
c, pivot body around the pick;
d, swing legs downhill;
e, the completed self-arrest.

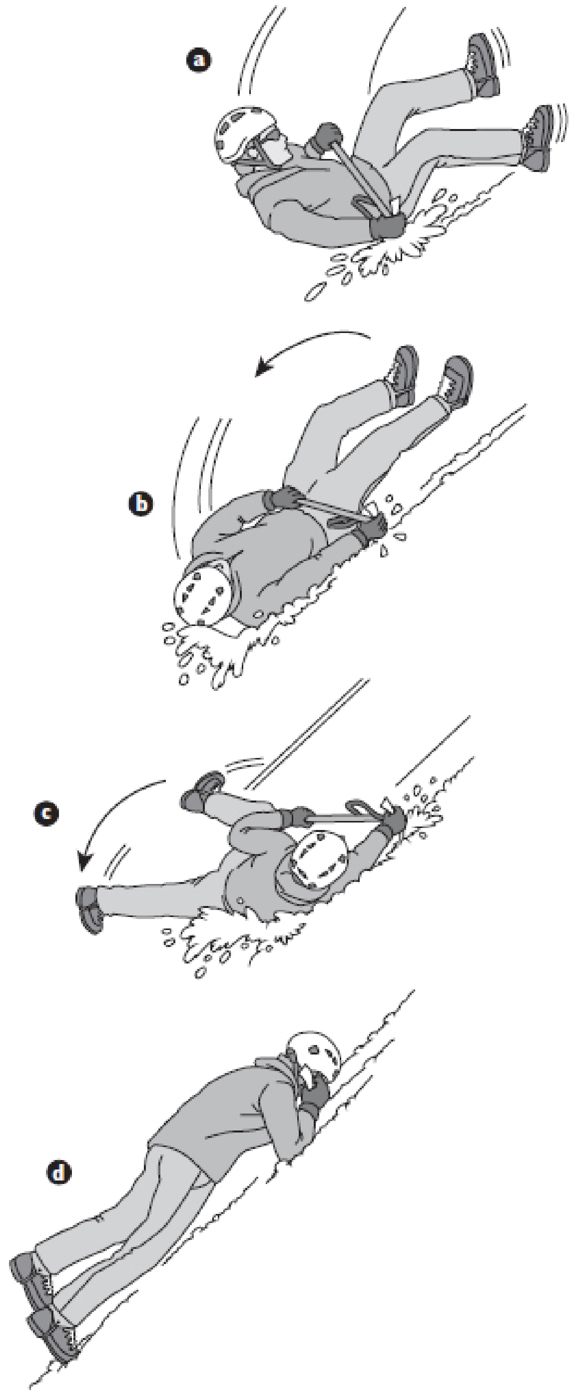

Fig. 16-28. Self-arrest technique, head downhill, on your back: a, plant the pick; b, twist and roll toward pick; c, swing legs downhill and roll chest toward pick; d, the completed self-arrest.

Without an axe. If you lose your ice axe in a fall, use hands, elbows, knees, and boots to dig into the snow slope, using positioning similar to what you would use if you still had the axe. Try to clasp hands together against the slope so that snow is accumulated in them and creates more friction.

Trekking poles provide minimal capability to arrest and are not advised. Trekking pole tips are not sharp like that of an ice axe for penetrating harder snow, nor do poles have the density and strength of an ice-axe shaft to aid in arresting. Trekking poles may be an aid on lower-angle slopes, used for balance, but they are ineffective in firmer snow or at steeper angles and should not be used with dangerous runouts.

Times when self-arrest should not be trusted include when a slope seems too fast or the runout too dangerous, or when members of the climbing party doubt their strength or skill. If this is the case, back off, look for another route, or rope up and put in protection. (See "Roped Snow Climbing Techniques" below.)

Crampons and Self-Arrest

It has traditionally been taught that wearing crampons when trying to self-arrest may not be a good idea, because they can catch and flip a climber over backward or even break an ankle. This may be especially true if the snow is hard or icy. Unfortunately, if climbers are on a slope where self-arrest may be necessary, there is a good chance they will want to be wearing crampons. This is also especially true if the snow is hard or icy.

The most important thing is to take action immediately and stop yourself. Crampons may actually help in executing a self-arrest in many snow conditions by providing more traction than boots alone, possibly stopping the fall before a person has achieved any speed. On an icy slope with a dangerous runout, a belay of some type is generally recommended instead of relying on self-arrest, but climbing parties have to assess the terrain and decide for themselves.

ROPED SNOW CLIMBING TECHNIQUES

On a glacier, teams rope up for protection from hidden crevasses. On a nonglaciated snow slope, the decision is not so clear-cut, and climbers have to weigh several options.

The party can climb unroped, relying on each individual to stop a personal fall. They may decide to travel roped together but unbelayed, which offers some security for a weaker climber and gets the rope set up in case no convenient rope-up place exists later. Or they may decide to travel roped together and to use belays, because route conditions or the climbers' abilities dictate this level of protection.

The risks of roping up are not trivial. One climber can fall and pull the entire rope team off the mountain. Risk of avalanche and rockfall exposure is also higher, and the party will move more slowly.

OPTIONS FOR ROPED TEAM PROTECTION

If the climbing party decides it is safer overall to rope up, several different methods allow a party to match the type of rope protection to climbing conditions and climbers' strengths.

Team Arrest (Roped But Unbelayed)

Team arrest depends on individual climbers to stop their own falls and to provide backup in case someone else falls. Relying on team arrest as the ultimate team security makes sense only in certain situations, such as on a low- or moderate-angle glacier or snow slope. The proficient members of the rope team can save a less skilled climber from a dangerous slide.

On steeper, harder slopes, the party has to decide which option is safest: continuing to rely on team arrest, using anchors for protection, or unroping and letting each climber go it alone. To increase the odds that team arrest will work on a snow slope, use the following procedures:

Carry a few feet of slack rope coiled in your hand if any climbers are below you. If a climber falls, drop the loose rope, which allows an extra instant before the rope is loaded; use this moment to get the ice axe into self-arrest position and to brace before the falling climber's weight impacts the rope. However, if too much slack is carried, the distance that your rope mates will slide before you stop them is increased, heightening the danger to your teammates and you due to momentum, dangerous runouts, or objective hazards close by.

Put the weakest climber on the downhill end of the rope. As a rule, the least skilled climber should be last on the rope while ascending and first on the rope while descending. This puts the climber most likely to fall in a position where a fall will be less serious: below the other climbers, where the impact will be felt quickly along the rope.

Climb on a shortened rope. This technique is best for a two-person rope team. A climbing pair that uses only a portion of the rope reduces the sliding distance and the tug from the fall if one partner falls. To shorten the rope, wind as many coils as necessary until the desired length remains. Then use a loop of the climbing rope to tie an overhand knot through the coils, and clip the loop in to your harness with a locking carabiner. Carry the coils over one shoulder and under the opposite arm. If more than two climbers are on the rope, the middle climber or climbers should take coils in the direction of the leader. (See "Special Rescue Situations" in Chapter 18, Glacier Travel and Crevasse Rescue, for a description and illustration, Figure 18-24, of a similar technique, called "climbing in coils.")

Climb in separate parallel tracks. This is another option that is best for a two-person rope team. The climbers are abreast of each other, separated by the rope. A falling climber will pendulum down, putting force on the rope to the side of and below the partner. The tug on the rope will be less than if the climber fell from high above. Also, the friction of the rope as it pendulums across the snow will absorb some of the force. On ascents where kicking two sets of steps would be a waste of time and energy, this style may be impractical, but on ascents of harder snow and on descents, it can be good.

Handle the rope properly. Keep the rope on the downhill side of the team so that there is less chance of stepping on it. Hold the rope in your downhill hand, in a short loop. You can then take in or let out the rope, adjusting to the pace of the person ahead of you or the person behind you, rather than getting into a tug-of-war.

Observe your rope mates' pace and position and adjust and prepare accordingly. When the rope goes taut, it may be hung up on the snow, or your rope mates may be in a delicate situation in which any additional tug on the rope could yank them off their feet.

Yell "Falling!" whenever any climber falls. This alerts all rope partners to self-arrest and avoid getting pulled off their feet.

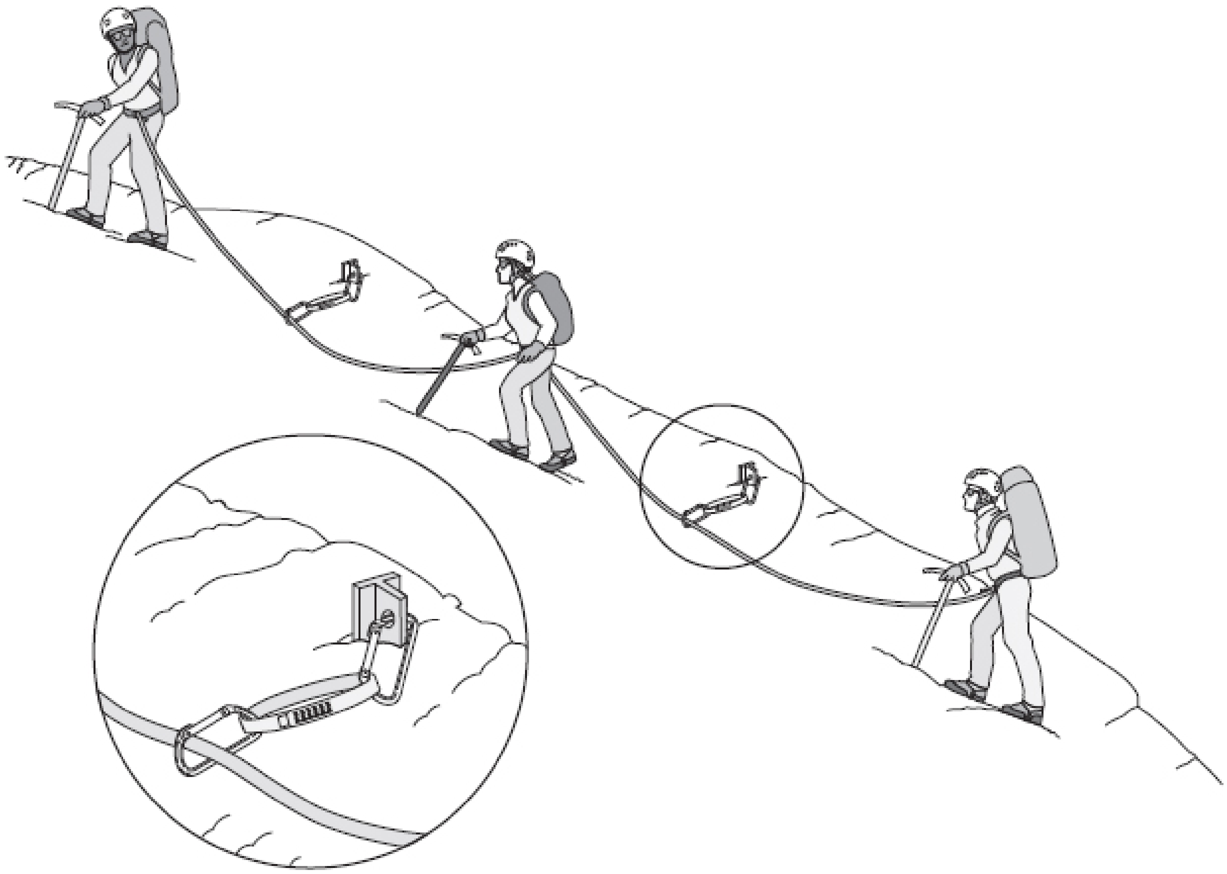

Fig. 16-29. A running belay setup; detail shows anchor attachment.

Running Belays

Roped climbers can move together on snow with the help of running belays. The running belay offers an intermediate level of protection, somewhere between team arrest and fixed belays. This technique saves time over regular belayed climbing but still allows for protection. Running belays, which are also useful in rock climbing, ice climbing, and alpine climbing, are discussed in Chapters 14, Leading on Rock, and 19, Alpine Ice Climbing. The running belay helps when a successful team arrest is improbable but fixed belays are impractical. For example, running protection may do the job on long snow faces and couloirs.

To place running belays, the leader puts in pieces of snow protection when necessary and uses carabiners and a runner to clip the rope in to each one. (For more information on snow anchors, see the next section.) All members of the rope team continue to climb at the same time, just as in unbelayed travel, except that now there is protection in the snow that will likely stop a fall (fig. 16-29). To pass each running belay point, when the middle climbers reach an anchor, they unclip the rope that is in front of them from the carabiner attached to the protection, then clip the rope that is behind them to the carabiner. The last climber on the rope removes each piece of protection.

Combination Protection Techniques

Long snow routes usually demand fast travel to reach the summit. Climbers often use a combination of roped and unroped travel, mostly unbelayed. They rely primarily on team arrest or running belays, and some sections of the climb will warrant unroped travel. Belays are typically used on steeper, harder snow or when climbers are tired or hurt. The option of turning around is always worth considering (see the "Decision Making for Roped Snow Travel" sidebar). The party can select a new route, choose another destination, or just head home.

DECISION MAKING FOR ROPED SNOW TRAVEL

A team always ropes up on glaciers, but on snow or mixed terrain the climbing team has a few considerations:

1. Is each member of the party able to use self-belay or self-arrest? If the answer is yes, the party can continue unroped.
2. Can the team stop all falls by roping up and relying on team arrest? If so, rope up and continue climbing unbelayed.
3. Can the team use some form of belay (running or fixed) that will provide adequate protection? If so, begin belaying.
4. Should the team turn around, or should the team either rope up or proceed unroped?

SNOW ANCHORS

Snow anchors provide protection and secure rappels and belays. The strength of a snow anchor placement depends on the strength of the snow. The greater the area of snow the anchor pulls against and the firmer the snow, the stronger the anchor. Ultimately, the strength of snow anchors depends greatly on proper placement and snow conditions. Common snow anchors are pickets, deadman anchors, and bollards.

Picket

A picket is a stake driven into the snow as an anchor. Aluminum pickets are available in lengths ranging from 18 to 36 inches (46 to 91 centimeters) and in different styles, including V- or T-profile stakes (Figure 16-30 shows a T-profile stake), with carabiner attachment holes at the end and (in many models) along the length of the picket.

The angle for placing a picket depends on the angle of the snow slope. The picket should be placed so that it can withstand the direction of pull while having the greatest possible area of snow to pull against. On a gentler slope, the placement should be vertical or at an angle of a few degrees toward the top of the slope. On a steeper slope, the placement should be at an angle of about 45 degrees from the direction of pull (fig. 16-30a). Drive the picket as far into the snow as possible with a rock, the side of an ice axe, or an ice tool hammer. Attach a runner to the picket at the level of the snow surface—not higher on the picket, or a pull may lever it out of the snow. A fully sunk ice axe or ice tool can also serve as a makeshift picket.

A picket works best in firm, hard snow. If the snow is too soft for a vertical top-clip attachment, place the picket with a vertical midclip attachment (fig. 16-30b). Clip the webbing to the middle of the picket and lean the picket upslope 45 degrees from perpendicular to the snow. Drive the picket down in the snow as far as possible and clear a trench just wide enough for long webbing and a carabiner to reach above the snow. The runner should be twice the length of the picket. The picket should compact the snow and dive down if stressed; but be aware that the angle could flatten out if it hits a hard layer, which would weaken the anchor.

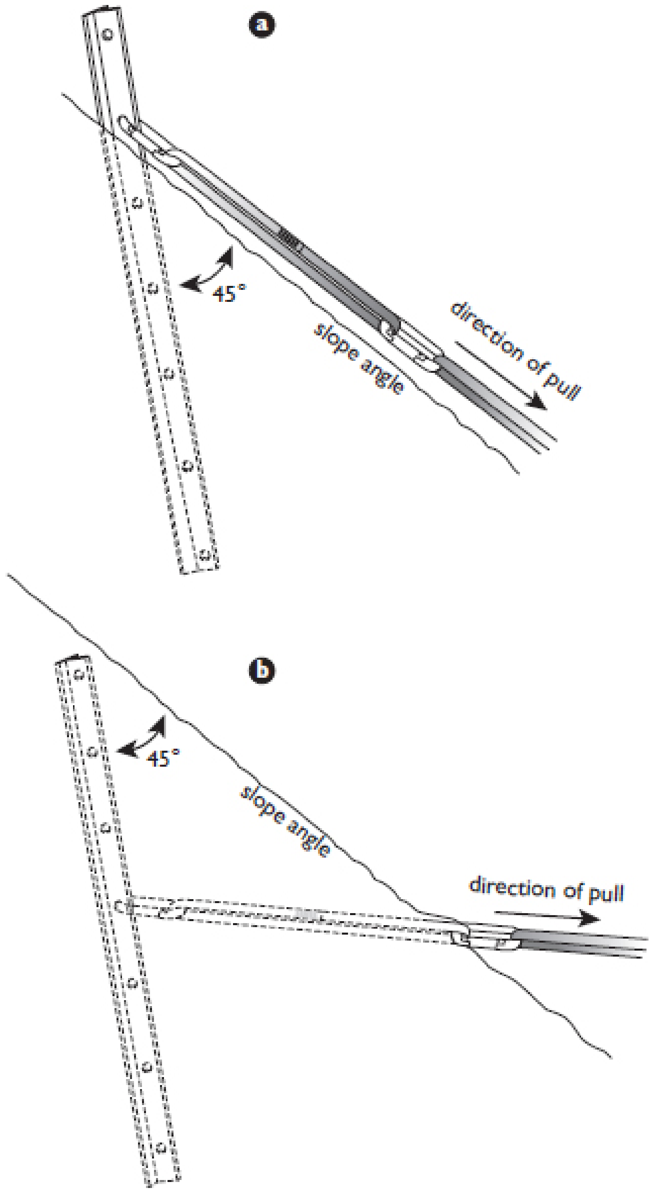

Fig. 16-30. The angle of picket placement varies with the steepness of the slope: a, in firm snow on a steep slope; b, in softer snow with attachment clipped to middle of picket. Note: Runner is not to scale—should be twice the length of the picket.

Another option is to use the picket as a deadman (see Figure 16-31a). Make sure the picket is not pulling out of the snow and that there are no visible cracks in the snow in the area against which the picket exerts force. Every member of a rope team using a running belay should check the picket as they pass it.

Deadman

A deadman anchor is any object buried in the snow as a point of attachment for the rope. Ice axes, ice tools, and pickets can be used as deadman anchors. Here are the steps to build a deadman:

1. Dig a trench as long as the item being used and perpendicular to the load.
2. Girth-hitch a runner to the item at its midpoint and place the item in the trench. To prevent the runner from sliding off the ends, use a carabiner. For a picket, clip a carabiner to the picket's midpoint and to the runner (fig. 16-31a). For an ice axe or ice tool, clip a carabiner to the hole at the spike end (fig. 16-31b).
3. Cut a slot in the snow that is as deep as the trench, to allow the runner to lie in the direction of pull. If this slot is shallower than the trench, there will be an upward pull on the anchor.

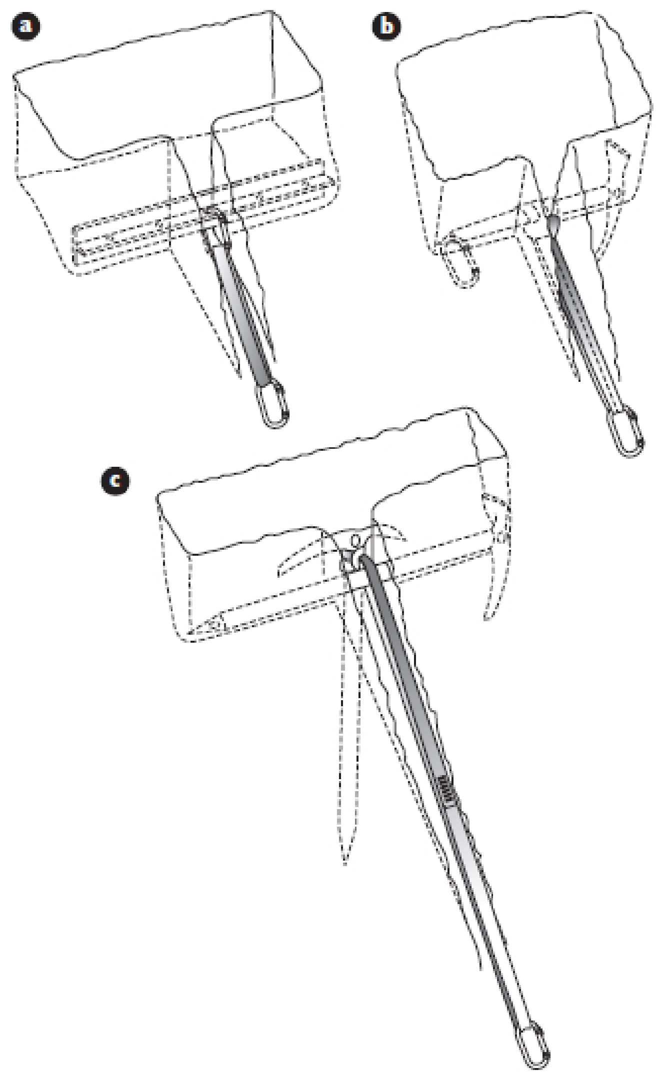

Fig. 16-31. Deadman anchors: a, picket; b, one ice axe, buried horizontally; c, the T-axe anchor, with two ice axes, one horizontal and one vertical.

4. Cover everything with snow except the tail of the runner. Stamp down on everything to compact and strengthen the snow.
5. Clip in to the end of the runner.

If the snow is soft, increase the strength of the deadman placement by increasing the area of snow it pulls against; do this by using a larger object. Try using a pack, a pair of skis, or a long, large stuff sack tightly filled with snow. Do not use ski or trekking poles—they are not strong enough. In a variation of the buried-axe deadman anchor, place a second axe vertically behind the horizontal axe (fig. 16-31c). In this variation, called the T-axe anchor, girth-hitch a runner to the vertical axe and run the shaft of the horizontal axe through the runner's loop.

As with all snow anchors, inspect a deadman after every use. Look for cracks and bulges in the snow above the buried item.

Snow Bollard

A snow bollard is a mound carved out of snow. When rigged with rope or webbing, bollards can provide strong, reliable snow anchors. However, building bollards can be time consuming.

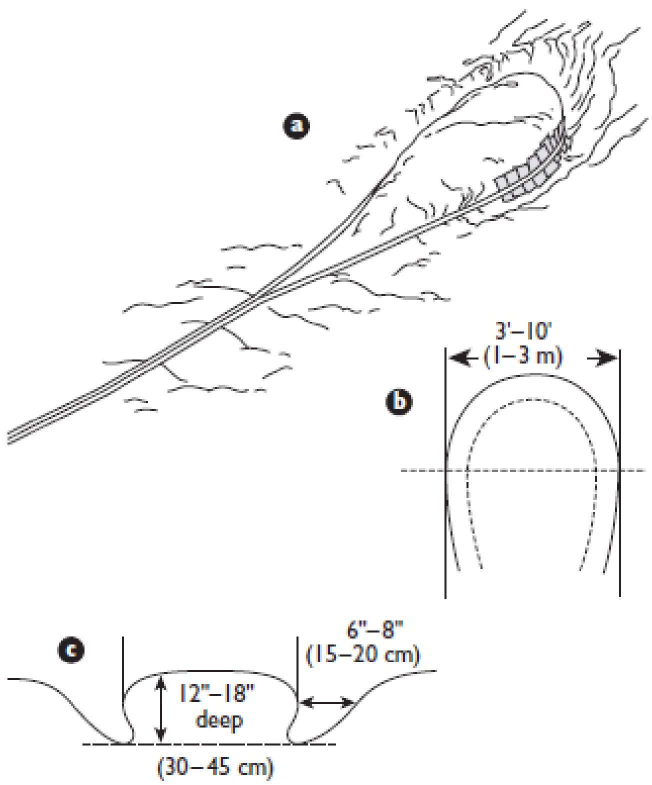

Fig. 16-32. Snow bollard: a, in a rappel setup; b, viewed from above; c, cross section.

Create the mound by making a horseshoe-shaped trench in the snow, with the open end of the horseshoe pointing downhill (fig. 16-32a). In hard snow, chop out the trench using the adze of an ice axe; in soft snow, stamp out a trench or dig one. In hard snow, the mound should be at least 3 feet (1 meter) in diameter (fig. 16-32b), and in soft snow it should be up to 10 feet (3 meters). The trench should be 6 to 8 inches (15 to 20 centimeters) wide and 12 to 18 inches (30 to 45 centimeters) deep (fig. 16-32c).

The bollard should not be in an oval teardrop shape in which the legs of the trench come together. This configuration results in a weaker anchor by not taking advantage of the entire snow slope in front of the mound.

During construction, assess the snow in the trench for changes in consistency or weak layers that could allow the rope or webbing to cut through the mound. Webbing is less likely than rope to saw into the mound. Avoid pulling on the rope or webbing after it is placed. Ice axes planted vertically at the shoulders of the trench prevent rope or webbing from cutting in. Pad the rear and sides of the mound with packs, clothing, or foam pads (as shown in Figure 16-32a). Inspect the bollard for damage after each use.

Multiple Anchors

Multiple anchors are safest. They can be placed one behind the other to provide backup and absorb any remaining force (fig. 16-33a), or they can be placed independently and connected to share the load (fig. 16-33b). Keep the anchors several feet apart so they do not share any localized weaknesses in the snow. Inspect every anchor after each use. (More details and illustrations on joining multiple anchors are found in “Equalizing the Anchor” in Chapter 10, Belaying, and in “Equalizing Protection” in Chapter 13, Rock Protection.)

BELAYING ON SNOW

When ascending on snow, climbers give quicker and less formal belays using an ice axe, or they set up belays using established snow anchors. No matter what the belaying technique, every snow belay should be as secure and dynamic as possible to help limit the force on the anchor. The hip belay can provide a more gradual, dynamic belay than a belay using a belay device, but it takes more practice to execute correctly (see “Using the Hip Belay” in Chapter 10, Belaying). Plan your stance so your body takes the force, which is dissipated as much as possible by the belay. The dynamic, shock-absorbing quality of climbing rope also helps to minimize chances of an abrupt stop to a fall.

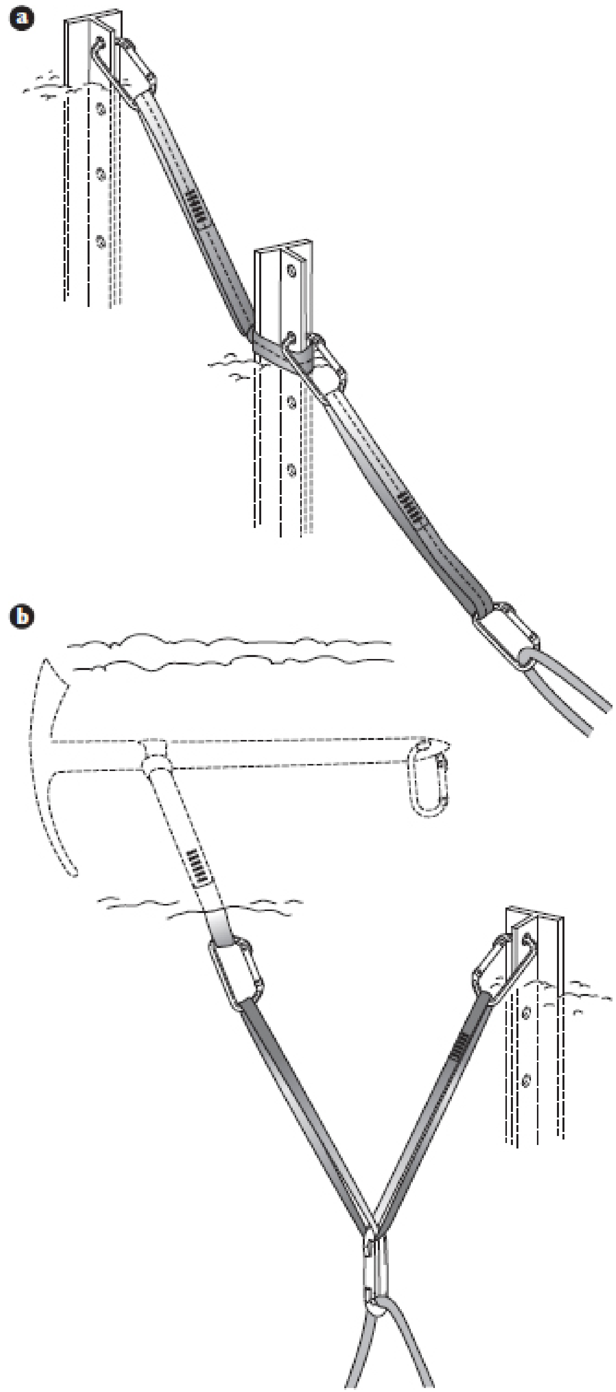

Fig. 16-33. Two methods of connecting multiple snow anchors: a, two pickets linked serially, with top anchor supporting lower anchor; b, two independent anchors with self-equalized connecting runner (sliding X).

Set up a belay close to the climbing difficulties. To belay the lead climber, get out of the line of fire by setting up the belay stance to one side of the fall line. If the leader is heading up on a diagonal, get outside any point where that climber's route can cross directly above you. On a ridge crest, it is not always possible to predict a fall line and plan a belay in advance. If a rope mate slips off one side of the ridge, the best tactic may actually be to jump off the opposite side, with the rope running over the ridge and thus saving both climbers.

Carabiner–ice axe belay. The carabiner–ice axe belay provides better security than a boot-axe belay (see below), with easier rope handling. One good thing about the carabiner–ice axe belay is that the force of a fall pulls the belayer more firmly into the stance.

To set it up, plant the axe as deeply as possible, the pick perpendicular to the fall line. Girth-hitch a very short sling to the axe shaft at the surface of the snow, and clip a carabiner to the sling (fig. 16-34a). Stand at a right angle to the fall line, facing the same side as the climber's route, with a control carabiner on your harness. Brace the axe with your uphill boot, standing atop the sling but leaving the carabiner exposed (fig. 16-34b). Keep crampons off the sling. The rope runs from the potential direction of pull up through the carabiner at snow level, through the control carabiner on your harness, and then around the back of your waist and into your uphill (braking) hand.

Fig. 16-34. Carabiner–ice axe belay:
a, girth-hitch a short runner to axe and clip carabiner to it; b, plant axe, stand on runner, and run rope up through carabiner and around waist.

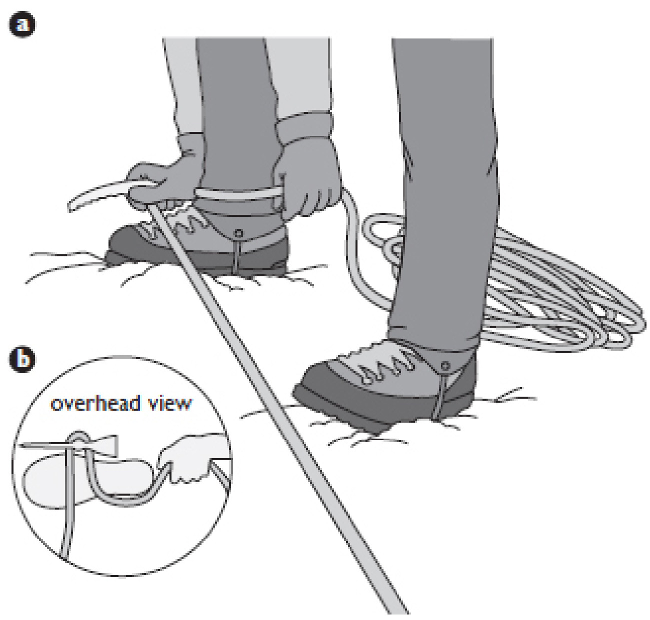

Fig. 16-35. Boot-axe belay: a, position of hands and feet; b, rope configuration.

Boot-axe belay. The boot-axe belay is a fast and easy way to provide protection as a rope team moves up together. The boot-axe belay, a form of dynamic belay, cannot hold the force of a high fall from above the belay, and because of the belayer's hunched-over stance, rope management is difficult. The boot-axe belay may be used to protect a rope mate who is probing a cornice or crevasse edge or to provide a top belay. With practice, this belay can be set up in a matter of seconds with a jab of the ice axe into the snow and a quick sweep of the rope around the shaft near the head, then in front of your ankle (fig. 16-35a and b).

Belay devices and munter hitch. Belay devices and the munter hitch used in conjunction with a snow anchor provide a very secure belay on snow. The belayer may be standing, sitting, or belaying directly off of the anchor, depending on a number of factors (see "Belay Position and Stance" in Chapter 10, Belaying). Consider belaying directly off of the anchor only when multiple anchor points are used. Standing and belaying from the harness or belaying directly from the anchor permits the belayer to get into a drier, more comfortable position. These belays are easy to set up and operate even with wet or icy ropes.

Fig. 16-36. Sitting hip belay.

Sitting hip belay. Used with a snow anchor, the sitting hip belay is dynamic and secure on snow. It does have its drawbacks. The sitting belayer may face the prospect of a cold, wet assignment, and the belay can be difficult to work if the rope is frozen.

To set up the belay, stamp or chop a seat in the snow as well as a platform to brace each boot against. Put down a pack, foam pad, or other material as insulation from the snow, and then settle into a standard hip belay, with legs outstretched and stiffened (fig. 16-36). (See "Using the Hip Belay" in Chapter 10, Belaying.)

ROUTEFINDING ON SNOW

Snow can provide passage over some frustrating obstacles, including tundra, talus, brush, streams, and logging debris. At its best it provides a smooth, uniform surface and a straight shot up the mountain.

At its worst, snow can be too soft to support your weight, or it can be hard and dangerously slick. It can obscure trails, cairns, ridge crests, and other guideposts to the route, especially above tree line. Dangers often lie beneath the surface: moats, creeks, or glacier crevasses hidden by a thin snow cover. Unstable snow slopes may avalanche.

Minimize the frustrations and dangers of snow travel by studying the medium. See Chapter 27, The Cycle of Snow, for information on snow formation, types of snow, and the creation of glaciers. Learn how seasonal weather patterns affect snow accumulation and avalanche conditions. Hone your navigation skills. Make the snow work for you: read the snow surface and terrain features to determine a safe, efficient route. If the terrain involves both snow and rock, leaving some tracks in the snow may help the party on the return trip.

ROUTEFINDING AIDS

A good routefinder uses a variety of tools, including map, compass, altimeter, GPS devices (see Chapter 5, Navigation), wands, the sun, and other visual landmarks.

SURFACE CONSIDERATIONS

The best snow to travel on is snow that will support climbers' weight and provide easy step-kicking, as well as being stable enough not to avalanche. The location of the best snow varies from day to day, even from hour to hour. If the snow in one spot is slushy, too hard, or too crusty, look around: there may be better snow a few feet away. Here are some tips for making the best use of the snow surface:

- **On a slushy slope,** walk in shade or use suncups as stairs to find patches of firmer snow.
- **On a slope that is too firm for good step-kicking**, try to find patches of softer snow.
- **When the going is difficult,** detour toward any surface that has a different appearance.
- **To find the best snow on a descent,** use a different route if necessary.
- **To find a firmer surface,** look for dirty snow. It absorbs more heat and therefore consolidates more quickly than clean snow does.
- **South- and west-facing slopes in the northern hemisphere** catch the heat of afternoon sun and consolidate earlier in the season and more quickly after storms. They offer hard surfaces when east- and north-facing slopes are still soft and unstable.
- **Take advantage of strong crusts on open slopes** before they melt. Get an early start after a clear, cold night that follows a hot day.
- **Beware of hidden holes** next to logs, trees, and rocks, where the snow has melted away from these warmer surfaces.
- **If the conditions are unfavorable on one side** of a ridge, gully, clump of trees, or large boulder, try the other side. The difference may be considerable.

VISIBILITY CONSIDERATIONS

The creative use of several routefinding methods becomes especially important when visibility is poor. In a whiteout, it is possible to lose all orientation. Distinguishing between uphill and downhill is difficult, as is distinguishing between solid snow and dense clouds. A whiteout can be caused by temporary cloud cover or blowing snow that limits visibility and makes navigation difficult and hazardous.

A GPS device can keep a party on track even when visibility is poor. Without GPS, care must be taken to avoid going off route. If a whiteout seems to be approaching, get out map, compass, and altimeter to navigate. Other options include placing wands, waiting it out a while before proceeding, or turning back.

TERRAIN CONSIDERATIONS AND FEATURES

Major terrain features present obstacles as well as opportunities (fig. 16-37). Know which ones to use and which ones to avoid.

Ridges

A ridge (fig. 16-37b) may be the route of choice if it is not too steep or craggy. Ridges are generally free of rockfall and avalanche hazard. However, ridge routes take the full brunt of wind and bad weather, and climbers must be alert to the hazard of cornices (see below), which form on ridge crests.

Cornices

Cornices form when windblown snow accumulates horizontally on ridge crests and the sides of gullies, hanging suspended out past the supporting rock (fig. 16-37d). The shape of a ridge determines the extent of the cornice that can develop. A ridge that slopes on one side and breaks into an abrupt cliff on the other is a good candidate for a gigantic cornice. A knife-edge ridge (where snow cannot accumulate) or a ridge that is gentle on both sides (where snow can disperse) typically has only a small cornice, if any at all—although exceptions do exist.

When the physical features are right for building cornices, wind direction decides the exact location of the cornice. Because storm winds have definite patterns in each mountain range, most cornices in the same area face the same way. In the Pacific Northwest region of the United States, for example, most snowstorms come from the west or southwest, so the majority of cornices form on the north and east sides. These same northern and eastern exposures were made steep by past glaciation, creating ridges ideally shaped for cornice formation.

There are exceptions. Temporary or local wind deflection can contradict the general pattern. In rare instances, cornices are even built one atop the other, facing opposite directions, the lower one partially destroyed and hidden by later formations.

Cornices are a hazard. If climbers are traveling on a cornice, it could collapse spontaneously or under the added load of their weight, or the climbers could break through the cornice. Collapsing cornices can trigger avalanches. Cornices can fracture, falling into gullies or along the slopes below, or they can separate slightly from their host ridge, forming a crack or cornice crevasse. (See Figure 17-5 in Chapter 17, Avalanche Safety.)

The safest course along a corniced crest is well behind the probable fracture line. Do not be misled by appearances. On a mature cornice, the probable line of fracture could be 30 feet (9 meters) or more back from the lip—farther back than might be expected upon examination. Usually the fracture line is not visible. Look for any crack or indentation in the snow, which might indicate a cornice that has partially collapsed and recently been covered with new snow.

The colder the weather, the more secure the cornice. A late-season cornice that is almost completely broken down also is not a problem. The safest strategy with cornices is to avoid them. Do not travel on them, under them, or through them.

Approaching from windward. The back side of a cornice appears to be a smooth snow slope that runs out to meet the sky.

Look at nearby ridges for an idea of the frequency, size, and location of cornices in the area. Try to view the lee side of the ridge from a safe vantage point, such as a rock or tree jutting through the crest.

Although rocks and trees projecting from the snow are safe, they do not indicate a stable route across the entire ridge. These can easily be on the tops of buttresses that randomly jut out perpendicularly to the ridge. The area directly in front of and behind these outcroppings may be all cornice. Many climbers have had the enlightening experience of looking back along a ridge only to discover that their tracks pass above a chasm.

When approaching from windward, stay well back from the crest if a cornice is suspected. If the crest must be approached, consider belaying the lead climber, who should probe carefully while advancing. The belayer also assumes a risk. If the cornice collapses, the belayer may have to bear the weight of the falling snow in addition to that of the climber.

Approaching from leeward. A cornice cannot be missed from the leeward side. Resembling a wave frozen as it is breaking, a large cornice close above a climber is an awesome sight. If a cornice's stability is doubtful, stay among trees or on the crest of a spur ridge while traveling below it.

Occasionally it may be necessary to climb directly through a cornice to force a way to a ridge crest or pass. Penetrate at an overhang, a rock spur, or a point where the cornice has partially collapsed. The lead climber cuts straight uphill at the point of least overhang, carefully tunneling and upsetting as little of the mass as possible.

Couloirs

Couloirs—steeply angled gullies (fig. 16-37t)—can provide a main avenue to the summit. Their overall angle is often less than that of the cliffs they breach, offering technically easier climbing. Couloirs are also the deadly debris chutes of mountains: snow, rocks, and ice blocks that are loosened by the sun often pour down couloirs (fig. 16-37ee). Here are some tips for using couloirs:

- **Try to be out of couloirs before the sun hits them.** They can be safer in early morning when the snow is solid and when rocks and ice are frozen in place.

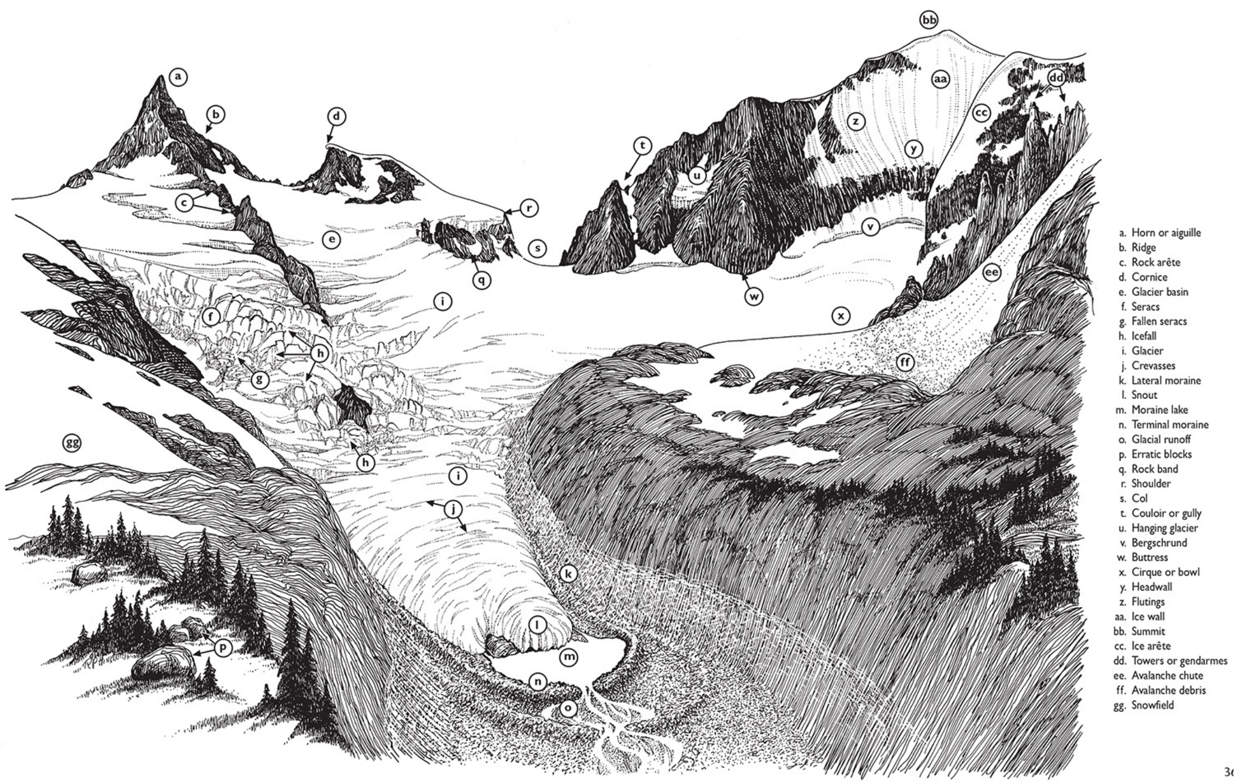

Fig. 16-37. Alpine terrain features.

- **Keep to the sides, because most of the debris comes down the center.**

- **Listen for suspicious sounds from above;** keep an eye out for quiet slides and silently falling rock.
- **Examine a gully carefully before ascending it.** Couloirs can become increasingly nasty higher up, with extreme steepness, moats (see below), rubble strewn loosely over smooth rock slabs, thin layers of ice over rock, and cornices.
- **Bring crampons.** Deeply shaded couloirs may retain a layer of ice year-round. Early in the season, they are covered by hard snow and ice caused by freezing or avalanche scouring. Later in the season, climbers encounter the remaining hard snow and ice, sometimes with steep moats lining its edges.
- **Observe snow and avalanche conditions above steep gullies and on their floors.** Avalanches scour deep ruts in the floors of many steep couloirs. Cornices can hang above. Early in the year, the floors of the ruts offer the soundest snow available, and in cold weather they may be quite safe, particularly for a fast descent. If these conditions do not exist, cross the ruts rapidly or avoid them altogether.
- **During the ascent, look for alternative descent routes,** just in case time or changing snow conditions prevent descending the couloir on the return.
- **Research the area beforehand.** Finding the correct couloir on a particular route can be challenging. They often look alike, and there may be several in the area. Rely on route information and knowledge of the terrain in order to choose the couloir that gives access to the summit rather than leading to a dead end.
- **Beware of meltwater streams running above or underneath the snow.** Listen for water. Look for sagging or holes in the snow where the stream may be. Walk on the sides of the gully and avoid any water; it may be slick with ice.

Bergschrunds

A bergschrund is the giant crevasse found at the upper limit of glacier movement, formed where the moving glacier breaks away from the permanent snow or ice cap above (fig. 16-37v). The downhill lip of the bergschrund can be considerably lower than the uphill edge, which may be overhanging. Sometimes the bergschrund is the final problem of the ascent. (See Chapter 18, Glacier Travel and Crevasse Rescue, for more information.)

Moats

Moats occur when snow partially melts and settles away from warmer rocks or trees. Moats are encountered on snowfields, around rock outcroppings and trees on ridges and along slopes, and in couloirs. Crossing a moat at the top of a snowfield where it separates from its rocky border can be as tough as getting past a bergschrund, with the main difference being that the uphill wall of a moat is rock, whereas the uphill wall of a bergschrund is ice.

Moats around trees and rocks may not be visible, appearing as merely an unstable layer of snow but actually covering an unseen large hole underneath. Stay away from treetops poking through the snow, and probe uncertain areas with an ice axe before stepping onto them. If a wide moat borders both sides of a slope along a steep couloir, it may indicate an equally wide moat at the head of the gully. Climbers may have to cross it or, worse yet, retreat and find an alternate ascent.

Rockfall

Snowfields and glaciers are subject to rockfall from bordering walls and ridges. Wear helmets in hazardous areas. Try to schedule climbs for less-dangerous periods. Early-season outings face less rockfall than summer climbs because snow still cements loose rock in place. In the northern hemisphere, southern and eastern slopes get the sun first, so climb these slopes early. The shaded northern exposures offer less rockfall danger.

SAFE SNOW TRAVEL

Snow is a constantly changing medium. Safe snow travel requires alertness, preparation, and a constant reassessment of conditions. Here are some points to remember:

- **Continually assess the runout and snow conditions.**
- **Do not rely on self-arrest if the runout is dangerous or unknown.** If climbers are uncomfortable using a self-belay, use a running belay or an anchored belay, or turn back and find another route.
- **Bring crampons on snow climbs,** even in warm weather. Crampons are not just for glacier travel. Climbers may encounter a shady couloir or slope with ice or hard snow.
- **Anchor the climbing party** if it has to adjust equipment, such as crampons, on an exposed slope.

- **Wear gloves whenever on snow,** even when the weather is warm and it would be more comfortable to take them off. A climber can fall at any time.
- **Yell "Falling!" whenever anyone, including you, falls.** Follow up with "Arrest! Arrest!" until the fallen climber has safely come to a stop.
- **Continually observe the party's overall condition and climbing ability.** Late in the day, exhaustion may diminish reaction time in the event of a fall.

GAINING FREEDOM OF THE SNOWY HILLS

Traveling across snow to reach a climbing objective is one of the most rewarding experiences in the backcountry. In summer, the excitement of encountering snow can be a delight, while winter snow creates a wonderland-like experience during pursuit of an objective. The basic techniques discussed here can help increase efficiency, safety, and enjoyment while traveling over snow. One additional factor is taking care in avalanche terrain. The next chapter provides some basic ideas on how to avoid avalanches when traveling or climbing under snowy conditions and on snowy terrain.