

End



NEW ANGLE ON GRAIN

End grain can bring a new perspective to working in wood. With a finish applied, the colors of domestic end grains are as vivid as the long grain of exotics, with striking textures and contrasts. Balance is important, though, when it comes to both looks and wood movement.

Photos, this page (bottom) and facing page: Kelly J. Dunton

Grain Up

Bring butcher's block out of the kitchen with these design and construction tips

BY MARK KOONS

I started working with end grain because it packs an intense visual punch and gave me a use for scrap pieces that would otherwise have been discarded. End grain also allows me to use domestic woods with renewed interest because it brings out different grain features and colors than can be seen in the long grain. I also discovered that end-grain slabs allow unique furniture forms (see “Add an apron and legs,” p. 78) that wouldn't be possible with long-grain construction.

End grain creates a very durable tabletop. Butcher-block countertops wear out knives before they need resurfacing, and finishes can wick deep beneath the surface of end grain, adding to its imperviousness. Of course, this quality isn't as important in a coffee table as it is in a countertop, but is it ever a problem to have a tabletop that's too durable?

Working with end grain up takes a good deal of planning, consideration of wood movement, and repetitive steps. But the results are worth the effort. I use end-grain construction in kitchenware, but this type of construction can be just as beautiful in high-end furniture as it is utilitarian in the kitchen. If you are intrigued by the possibilities of end grain, here's what you need to know.

Arrangement of wood is key to success

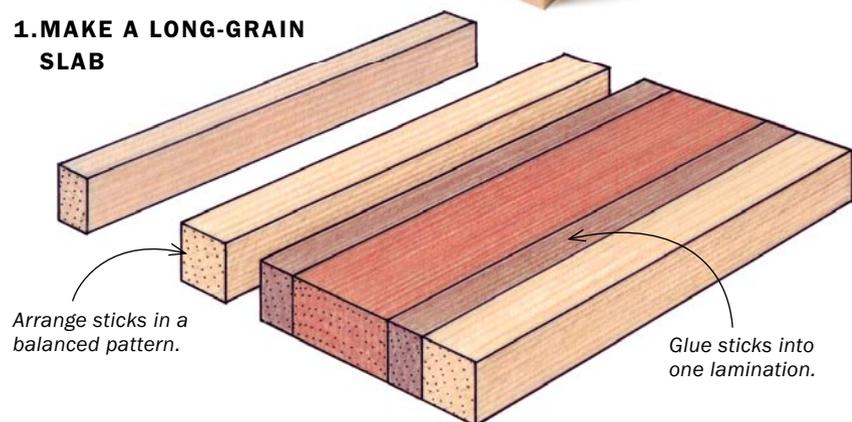
The greatest challenge to this work is wood movement. Wood always expands or contracts with changes in humidity. The solution is balancing the construction—arranging the parts based on grain direction.

You could put the pieces together without considering their orientation, but that randomness would lead to an unstable slab. For example, instead of

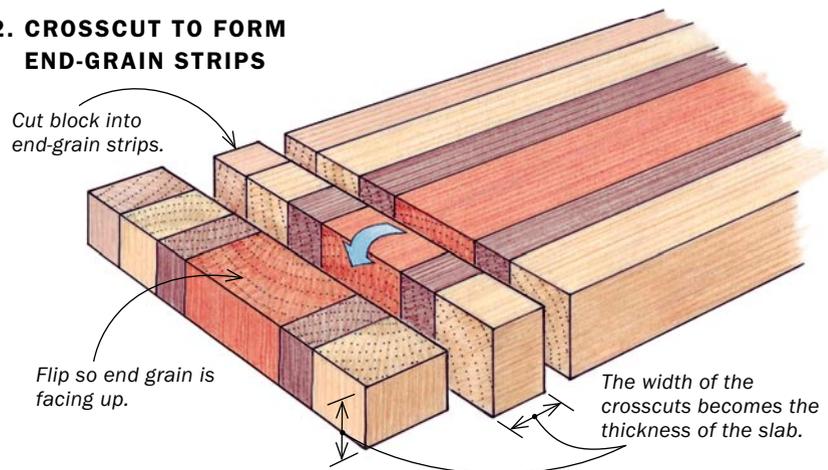


THE BASIC STEPS

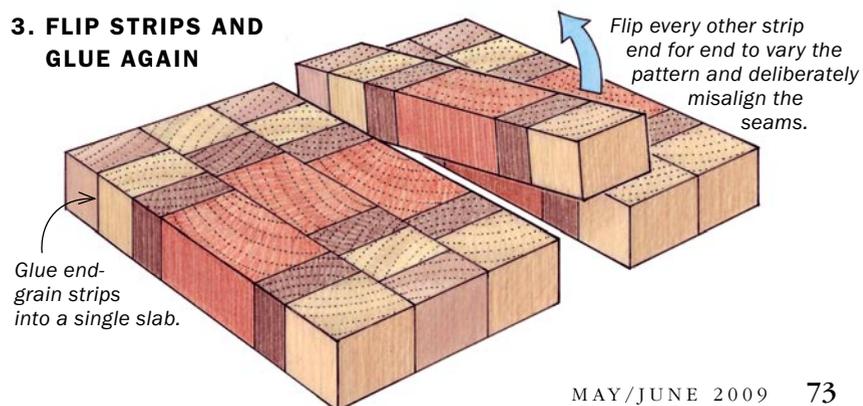
1. MAKE A LONG-GRAIN SLAB



2. CROSSCUT TO FORM END-GRAIN STRIPS



3. FLIP STRIPS AND GLUE AGAIN



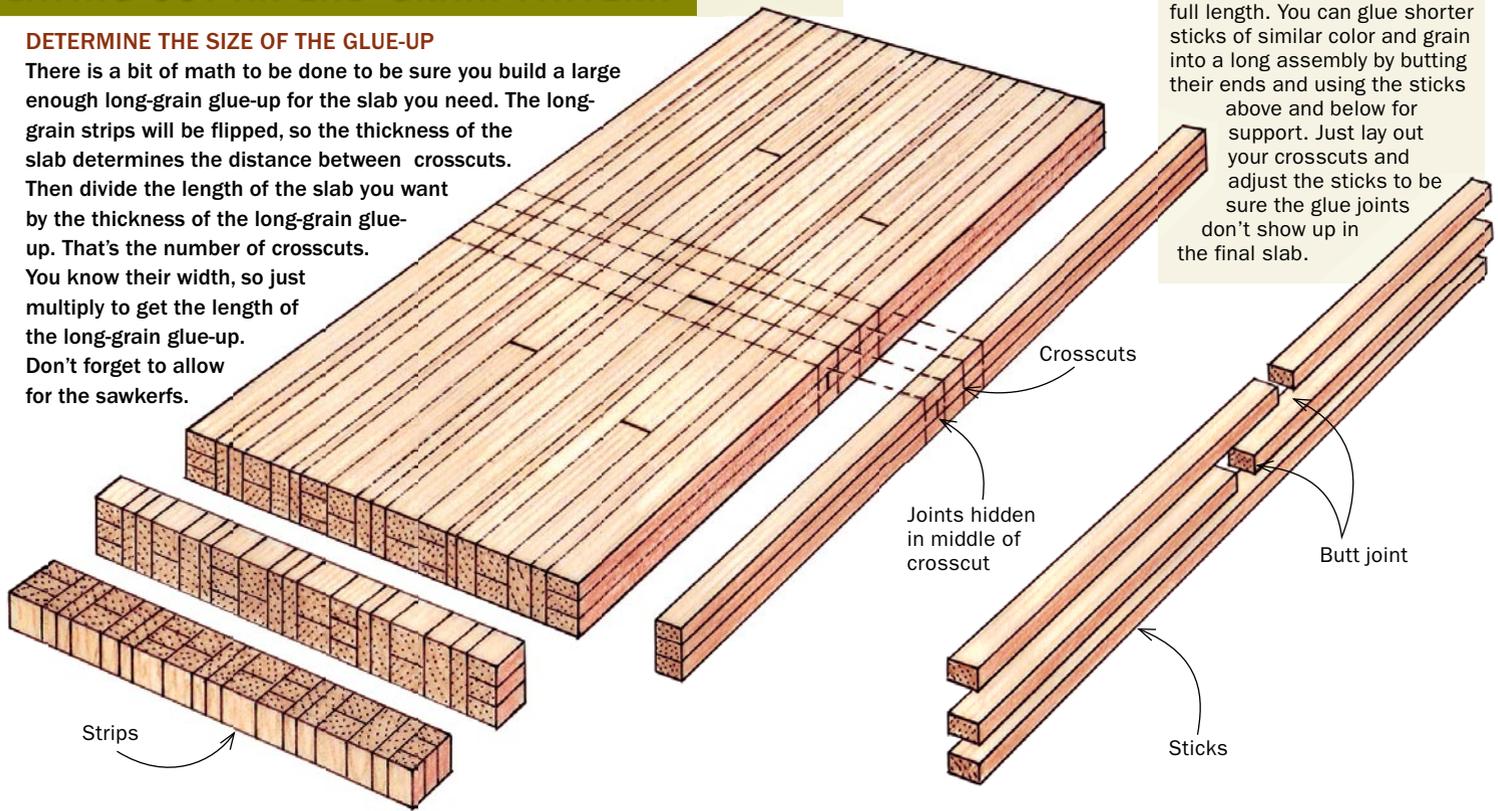
LAYING OUT AN END-GRAIN PATTERN

TIP

Not all the sticks need to be full length. You can glue shorter sticks of similar color and grain into a long assembly by butting their ends and using the sticks above and below for support. Just lay out your crosscuts and adjust the sticks to be sure the glue joints don't show up in the final slab.

DETERMINE THE SIZE OF THE GLUE-UP

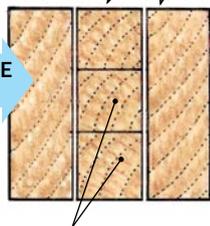
There is a bit of math to be done to be sure you build a large enough long-grain glue-up for the slab you need. The long-grain strips will be flipped, so the thickness of the slab determines the distance between crosscuts. Then divide the length of the slab you want by the thickness of the long-grain glue-up. That's the number of crosscuts. You know their width, so just multiply to get the length of the long-grain glue-up. Don't forget to allow for the sawkerfs.



BALANCE THE GRAIN

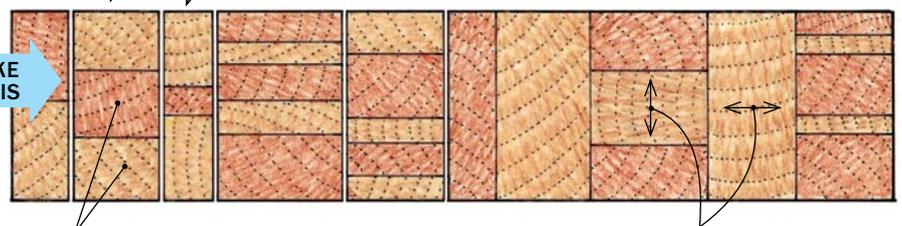
The force of all the grain in these pieces moving in the same direction could be strong enough to pull apart the glue joints.

NOT LIKE THIS



Grained is aligned.

LIKE THIS



Pieces with grain that flows to the left are balanced by those that tend toward the right.

Expansion and contraction are far greater in the direction of annular rings than across them, therefore flatsawn stock is balanced by quartersawn stock.



Check the seams. After crosscutting, alternate end-grain strips will be flipped end for end to create a repeating pattern. If any seams line up, they will be aligned all the way down the length of the end-grain pattern. To prevent this, Koons double-checks his array of long-grain strips with a ruler that starts at zero in the center and counts outward in both directions.

deliberately arranging annular rings so that they alternate in direction and restrain each other's movement, you could end up with a row of end grain that all moves in the same direction. If you compound the problem in the adjoining row, the laminations will pull apart in about one year's time.

Keep in mind that smaller overall slabs accumulate less internal stress than large ones. Also, thinner assemblies generate less stress than thicker ones. So the thicker or larger an end-grain construction, the greater its tendency to move and surface check if the grain isn't arranged carefully.

Beginners also should consider that a single-species lamination, especially of some relatively stable wood like walnut, will be easier to lay out than one patterning a range of species with different expansion properties. Also, you can get plenty of contrast from the grain patterns and colors of a single species, while it's easier to create an eyesore when mixing woods.

1. GLUE UP THE STICKS



Be generous with glue. Use a squeeze bottle and roller to spread glue on both faces. For a large surface that requires longer working time, glue half the lamination first and add the other half after it dries. Do a dry run to work out the arrangement and pre-adjust the clamps, then apply glue. Set the horizontal clamps in place, but don't tighten them. Loosely clamp the top cauls to the bottoms, and then loosely tighten the horizontal clamps. Now, snug the top and bottom clamps down tightly and go back to tighten the horizontals.



CROSSCUT INTO END-GRAIN STRIPS



Begin crosscutting at the center. To make the slab more manageable and reduce cumulative error across the top, crosscut the slab at the center (left). Then reference off the rip fence to cut the rest of the strips to the same width (right).



Different wood species have different rates of tangential (parallel to the growth rings and perpendicular to the grain) and radial (perpendicular to growth rings) shrinkage. So if you do mix woods, species that are stable should be used to restrain those that are less stable. You can research the stability of different species in R. Bruce Hoadley's *Understanding Wood* (The Taunton Press, 2005) or at the Web site of the Forest Products Laboratory (www.fpl.fs.fed.us).

Butcher-block assembly made easy

Creating fields of end grain does not require fitting together hundreds of little cubes. Nor does it involve sawing off laminations like slices of salami, although

some manufacturers do exactly that. My process involves two big glue-ups: a long grain glue-up and then an end-grain glue-up. Basically, I glue sticks together, surface and crosscut them, and then reglue them as end grain.

Arrange the sticks—First, I rip the sticks to width. Before any glue is spread, I arrange the components, balancing them the way I described earlier, to make good visual and structural sense in the final assembly. I pay attention to grain, widths of the sticks, species, and color. Once I settle on an arrangement, I mark the sticks with a soft pencil to keep track of the order. Throughout the process, I continually mark the pieces to keep them arranged in the

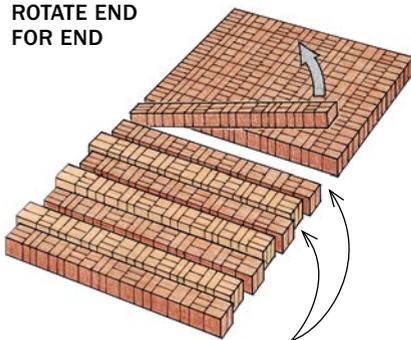
Clean up the end-grain strips. Take the end-grain crosscuts and skim about $\frac{1}{16}$ in. off one side with a ripcut on the table-saw. Then move the fence to take another skimming ripcut on the other side. If your gluing, clamping, and ripping were carefully done, you won't have much to clean up.

2. GLUE UP END-GRAIN STRIPS

Mark, flip, mark, glue. Put the end-grain sticks back in their original order and mark them (right) so you can easily reorder the sticks after experimenting with different flips. You can flip and rotate, or just flip. Here, Koons flips every other stick upside down and end for end (below).



ROTATE END FOR END



Flip every other piece to orient the pattern and balance the stresses.



correct order. In determining the length of your sticks and crosscuts, it's important to make note of the relationship between the thickness of the first lamination (the long-grain slab), the width of the subsequent crosscuts, and the overall thickness and length of the tabletop. The thickness of the long-grain slab will determine the width of the repeating end-grain pattern on your tabletop. The width of the crosscuts of the long-grain slab will determine the thickness of the top.

As an example, if I wanted to build a tabletop 1 in. thick by 24 in. wide by 36 in. long, I could begin by making a long-grain slab that was $2\frac{1}{8}$ in. thick by about $24\frac{3}{16}$ in. wide (leaving a little extra to trim the assembly square later). For the 1-in.-thick top, I would make my crosscuts $1\frac{1}{32}$ in. But how long should I make the long-grain slab? If the crosscuts are a heavy 1 in. and they get turned end grain up so the $2\frac{1}{8}$ -in. pattern is facing the top and bottom, then I'll need at least 18 in. plus the amount of 15 sawkerfs for the length of the long-grain lamination. But why cut it close? Make the lamination longer than you need, even if that means a few extra crosscuts kicking around.

Glue and clamp the sticks—Once the assembly is arranged, it's time to glue the sticks into one wide, long board. Some of the sticks are made from multiple layers, and some of those are made of short sticks butt-jointed and held in place when glued to the adjoining layer. Those multilayered sticks must get jointed and planed before becoming part of the larger glue-up.

The cauls should be very straight and sturdy to prevent flexing, as they will determine how level the glue-up is. The lower cauls rest between pipe clamps and hold the work up off the bench and slightly above the clamps. The upper cauls have a layer of cork on the bottom side that helps press the work flat against the lower cauls. Make sure all the cauls are stick-free by taping or waxing.

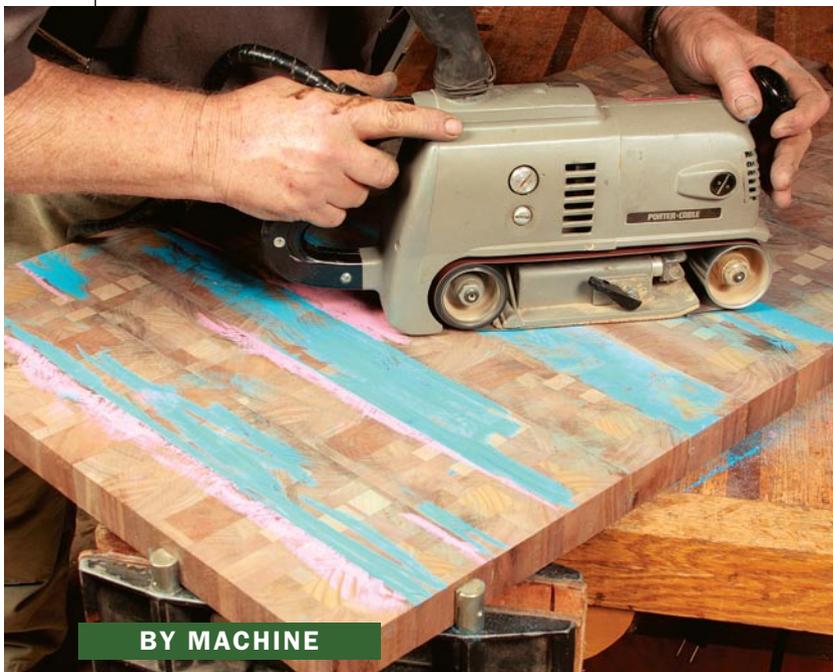
You'll need a flexible adhesive. Yellow glue is notorious for cold-creep, the tendency for a glue to allow slow but inevitable movement over years. Here, that is an asset because it stretches when the wood expands and contracts as the wood does.

Surface then crosscut vs. crosscut then surface—Once the sticks are glued into a slab, you can make the crosscuts that establish the end-grain surface. This is a crucial place for quality machining. The more variation here, the more effort it will take to smooth the surface. You'll need a clean, sharp blade squared to the table, a zero-clearance throat plate, and a sacrificial backup fence on your crosscut sled or



Glue them back together. Use the same procedure as you did with the long-grain lamination to glue up the end-grain sticks. Taking the time to tape all the seams before the glue-up will keep the glue from seeping into the end grain and save you cleanup time later.

3. SMOOTH THE SLAB



BY MACHINE

Sanders are one option. Use different colors of chalk to mark the high spots and low spots. Using a belt sander, begin to remove the high spots only (above). Stop to reassess the surface with a straight-edge and re-mark the high spots to sand again. Repeat until the surface is flat. The final surfacing is done with a random-orbit sander (right).



BY HAND

Or use handplanes. The low angle and very sharp blade of this jack plane leave a smooth, refined surface. Put an arc, or camber, in the plane iron to keep the edges from digging in, and work from the outside in to avoid breakage on the edges.

miter gauge—elevated a little to keep dust from affecting the width of the crosscut. Ideally, you'll want no burn marks or saw flutter on your cuts. Every 0.001 in. error is 0.001 in. you'll have to work off across the entire slab later.

Remove the clamps and scrape off the excess glue while it is still rubbery. If you have a planer wider than the slab, use it to surface the board before making end-grain crosscuts.

If your planer isn't wide enough to accommodate the tabletop, you'll have to clean up the surface with a scraper, crosscut first, and then use my tablesaw trick (see bottom right photo, p. 75) to lightly skim the surfaces of the crosscuts before regluing them into the final end-grain lamination. Once you've cleaned up all the sides of the end-grain strips,

Two finishing options



A finish fit for furniture. Koons uses four to six coats (depending on how porous the wood is and how thin the finish) of a spar varnish/tung oil mixture to finish end grain in furniture. Before that, he seals the end grain with blond shellac to keep the colors vibrant and clear under the varnish.

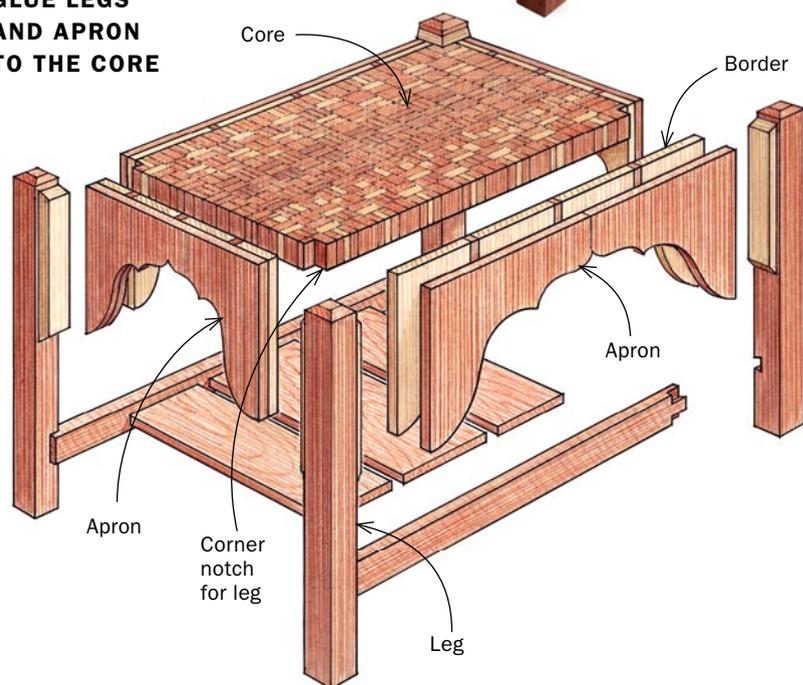


One suited for the kitchen. A beeswax-walnut oil blend, about 1 oz. wax to 3 oz. oil, is ideal for kitchenware. This combo is fragrant, non-toxic, attractive, easily renewed, and cheap. Apply generously in a circular motion and wipe off the excess.

ADD AN APRON AND LEGS

Because of the end-grain orientation, legs, a border, and an apron can be glued directly to the top. The legs could be notched directly into the top, but for a minimal investment of time, the border and apron dress up the core and add the appearance of depth to the entire top.

GLUE LEGS AND APRON TO THE CORE



arrange them back in order and witness-mark them. Now flip every other strip end for end and upside down, use a straightedge on the edges and a square on the end to square up the whole arrangement, and witness-mark them again. Align this mark in the final glue-up to keep the end-grain sticks square. Now you're ready to glue the crosscut strips into the final slab. Use the same procedure for the final gluing that you used when you glued the long-grain sticks together; but this time, the cauls and clamps run lengthwise.

Surfacing end grain

Because end grain is more durable than long grain and can be dangerous to run through jointers or planers, it takes a bit more work to surface. If you have your own wide-belt sander, then you are in luck. Renting time on a wide-belt sander is also an option, but short of that I've had success with a belt sander and random-orbit sander, as well as with handplanes.

If you don't use a belt sander often, practice gliding the running sander squarely onto a test piece and backing off while slipping it sideways. On the actual workpiece, mark the high and low spots, grind away the high spots, and continually stop and check your progress with a straightedge, re-marking if necessary. Begin with 60- to 80-grit paper and move up to 220 grit on the belt sander. Clean and inspect the surface for uniform scratching before changing to a finer grit. When the defects are ground away and the surface is flat, move to the random-orbit sander, beginning with 80 or 100 grit and proceeding through 220 grit.

A well-planed surface is always the most beautiful. If you have a low-angle jack plane—even a low-angle

1. START WITH THE APRON



Create a border and apron. After edge-gluing boards for one border and one apron per side of the table, laminate the border to the apron (left), and then use a scrollsaw or bandsaw to cut the shape of the apron (right). Sanding and filling will refine the shape.

Apply the apron. Working on one side at a time, clamp the apron in place and predrill and tap in a brad to locate the apron during the glue-up (left). Koons left the inside border slightly wider to accommodate the nail. Any excess material gets trimmed off when notching for the leg, which will cover the nail hole. Make sure the apron is square to the tabletop (right).

2. NOTCH FOR THE LEGS

No. 4 block plane will work—sharpen it well (expect to go back to your stones frequently), ease the corners of the blade, and work from the outside edges of the workpiece toward the center. In some ways it's easier to plane end grain because you don't have to worry about reversing grain. I've also had success with a standard-angle No. 7 plane equipped with a very sharp Hock iron.

A different approach to aprons and leg joinery

Long-grain tabletops are typically attached to a leg-and-apron system, and that type of assembly can be done with an end-grain tabletop as well. But end-grain work offers an alternative. Legs and aprons can be glued onto the edges of an end-grain slab. My method happens after the core tabletop is completely glued together.

At the same time as the apron, I add a border of the same width and length to my construction. It sits outside the table core but inside the apron and creates a transition between the tabletop pattern and the outside apron.

To create a border/apron combination, start by edge-gluing sticks into sections that fit the sides of the core. Keep in mind that you still have to balance the arrangement of the sticks in the border/apron construction. Once those sections are dry, laminate them to one another. Use a scrollsaw to cut the shape, and files and sanding drums to refine it. Then glue and clamp the apron assembly to the core.

Once the apron is secured on the core, I use my sliding tablesaw to cut corner notches for the legs. Don't worry if you don't have a slider on your tablesaw. Before I had one I used a shopmade crosscut sled to carry the tabletop assembly across the blade while notching out for the legs. Assuming a pair of miter-gauge slots and an extension to the right and behind the sawblade, make the sled out of two hardwood strips 20 in. long and two fences 2¼ in. by 5½ in., the front one about 16 in. long and the back one about 60 in. long.

You can assemble the sled right on the saw by gluing the fences square to the guide strips and the blade, then flipping the assembly and screwing the joints before the glue is fully cured. □

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Cut the notch. Koons adds a higher, longer fence to the crosscut fence on his sliding tablesaw. It adds stability and extends the slider to the other side of the table, which is necessary because various cuts are made with the table extending to each side.



Glue the legs in place. Taping anywhere squeeze-out will seep onto the end grain or surrounding area will save you cleanup time (above). Once the leg is glued in place, apply clamp pressure in both directions (right).

