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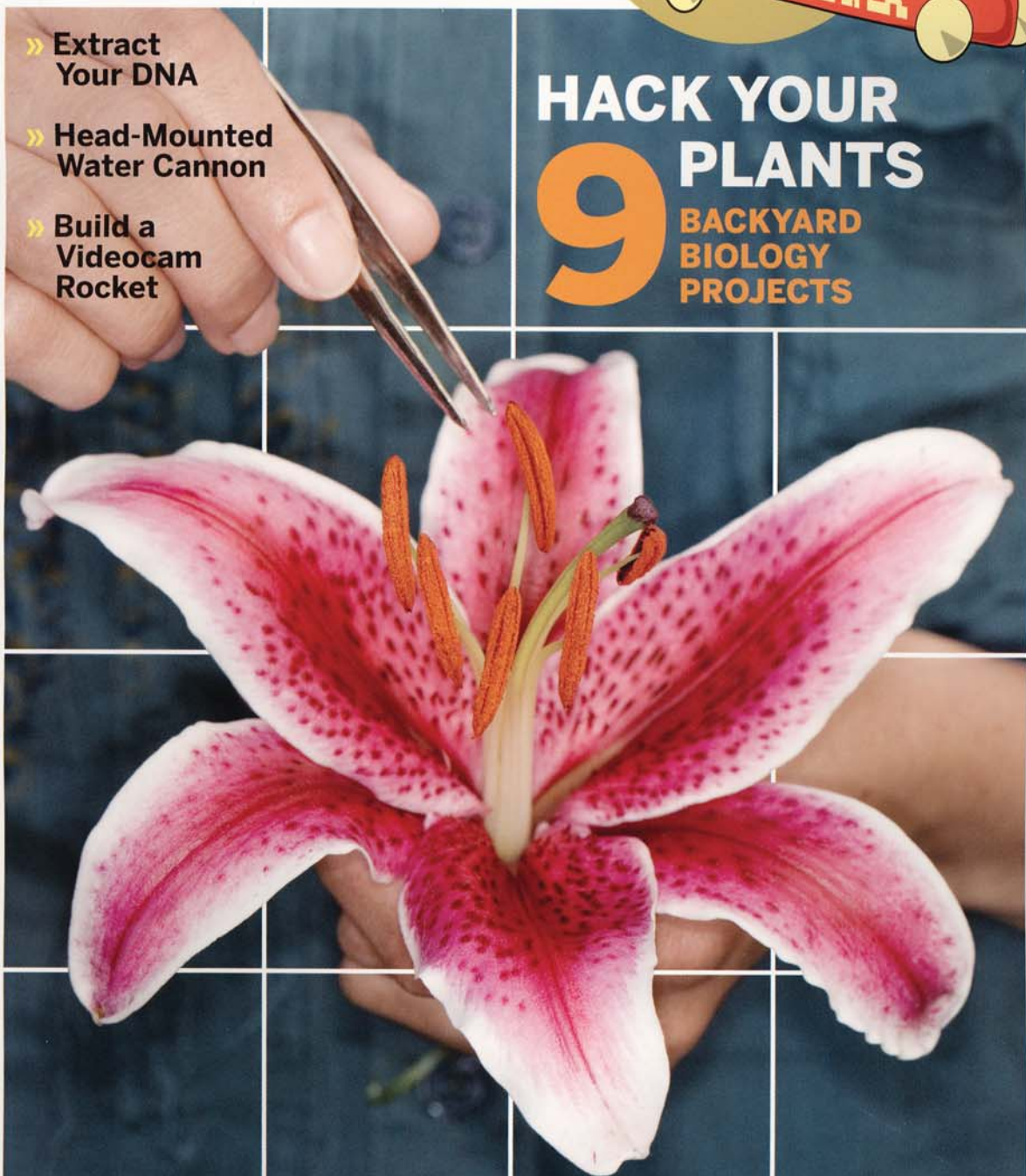
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HACK YOUR PLANTS

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Hack Your Plants!

Play God in your garden — create custom fruits, flowers, veggies, and more. By Robert Luhn

Joe Real's backyard looks normal enough — a tidy rectangle of carefully trimmed grass with dozens of fruit trees lining the perimeter. But look closer: almost every tree looks like it fell down a flight of stairs, the limbs snapped off and replaced with new ones held in place with tape and rubber bands.

Welcome to the world of plant hacking. In Real's case, we're talking about grafting: the art of taking limbs (or even buds or chips) from one plant and suturing them onto another, to grow two or more varieties on the same plant.

One pear tree in Real's yard is growing 24 kinds of pears; another has two kinds of pears, two kinds of apples, and five varieties of quince hanging from its limbs. The centerpiece is a single citrus tree groaning under the weight of 48 different kinds of oranges, lemons, limes, and grapefruits. (The tree is currently being certified by Guinness World Records.)

METHODS AND MADNESS

Grafting's advantages are clear: it's a cheap, fast way to grow a cornucopia of plants in a small space. If you grow a tree from a seedling or sapling, you may have to wait four or five years for it to bear fruit; graft a stem from a mature tree, and you may get fruit next year. For gourmands like Real, it's a way to savor rare, mouth-watering fruit and vegetables year-round.

But grafting is a bit like collecting art. If you want to get more creative, the next step is crossbreeding — mating two different plants to create a unique offspring called a hybrid. With time, careful observation, and a bit of luck, you might produce a never-before-seen geranium; a newer, sweeter watermelon; or, alas,

something god-awful. As one botanist put it, plant breeding is "a science that requires art."

HACKING THE HACKER

So why become a plant hacker?

"Everyone wants to put their hand on nature," says Todd Perkins, a flower breeder at Goldsmith Seeds. "It's primal. And there's the joy of taking infinite diversity and selecting just those traits you want."

Some of those traits might include creating a plant that blooms longer, can be harvested earlier, tastes better, is resistant to pests and disease, comes in groovy shapes and colors, or simply stands up straighter (a desirable trait in corn, for example).

But newbies and digerati, take note. This is no virtual experience — you're hacking life, sometimes literally, with a saw, and sometimes subtly, with a tiny brush coated with pollen. It's as tangible as life gets — we're talking dirt, bugs, plants, knives, saws, and, of course, sex.

P.S.: To get a handle on plant anatomy, check the handy diagram at makezine.com/go/anatomy.

IF YOU WANT TO GO DEEPER

We don't delve into techniques here that require fancy lab equipment, mutation-inducing chemicals, or a degree in molecular biology. For example, tissue culturing, mostly used for creating disease-free clones of a plant, can be used to merge individual cells from two distantly related species to create a new plant. If you want to take this plunge, check out the kits at kitchenculturekit.com.

We also don't wander into the realm of full-blown genetic engineering techniques. For that, you need more education and moola than called for here.

MAKING THE HACK

Grafting

With grafting, hack is the operative word. You basically splice a bud or a stem (called the *scion*) onto a plant with established roots (referred to as the *rootstock*). If you make a good fit between the active cells on the scion and rootstock (the *cambium*, the layer of cells right behind the bark) and you keep 'em in a moist, loving embrace, the two will eventually merge and form a solid connection in just a few weeks. The result: a new, strong branch that will grow a different fruit, flower, or whatever, on that plant.

Bud Graft

Hack the plant: There are dozens of grafting techniques, but we'll step through two of the classics: bud grafting and whip grafting.

A bud graft is the way to go if you don't have a lot of material to work with (like an entire stem) or you want to graft later in the year (midsummer and fall). Bud grafting works especially well with fruit trees and ornamental trees (such as magnolias).

First, select a stem that's about as thick as a pencil. Then, sterilize your knife with the isopropyl. About $\frac{3}{4}$ inch below a bud, cut $\frac{1}{4}$ inch into the stem at a 45-degree angle, and pull the knife back in a straight motion. Make a nice, flat cut, so the bud's cambium will cleanly make contact with the rootstock's cambium. When you cut the bud out of the stem, leave about $\frac{3}{4}$ inch of bark above the bud. You should end up with a bud sitting on a little rectangle of bark. Flip it over and remove any woody material.

Next, on the rootstock, take your knife and cut a "T" into the bark that's a bit bigger than the bud, and spread open the bark like little doors. Tuck the bud into place, as if you were slipping a foot into a shoe, and then let the flaps of bark cover it. Then, use grafting tape to secure the graft; wrap around and underneath the bud several times, and over the top once. (Don't put the tape on the bud.) Give the tape a good yank at the end, and it'll stretch and stick nicely to the rootstock. The graft is done! Finally, cut off anything above the bud graft on the rootstock; this will force the plant to devote more resources to the graft.

Tools of the trade: Grafting knife, grafting tape such as Parafilm Grafting Tape, anvil-style pruning shears, a hacksaw (if you're grafting trees), isopropyl alcohol for sterilizing all blades before and after a graft, and a wound sealant such as Doc Farwell's Grafting Sealant.

Rules of the road: The plants you're melding should be closely related, or the graft won't take. Typically, you can graft plants from the same genus (such as members of *Prunus*: cherry, plum, apricot), and certainly from the same species. The rootstock should be about 2 years old — old enough to have an established root system, but young enough to still be growing like a teenager. The stem or bud you graft onto the rootstock should be dormant, which is why you typically graft in late winter or early spring.



1. Remove a bud from a stem.
2. Flip over the bud and remove any woody tissue. The result should look like this — clean, green cambium.
3. Cut a "T" in the bark, pull back the bark (to reveal the cambium), and then slide the bud into the space (its cambium side down), like a foot into a slipper.
4. Wrap the graft: three times below the bud, once above.

Whip Graft



1. To make a whip graft, use a sloping cut at the bottom of the scion and a matching cut at the top of the rootstock.
2. Fit the two matching pieces together.
3. Wrap the graft with grafting tape.
4. Then apply grafting sealant to heal the wound and keep moisture in.

TIPS, TRICKS, AND TRAPS

Grafting is pretty straightforward, even for someone who's all thumbs (like me). But plant pros (like the Plant Science professors at UC Davis) and avid amateurs (like Real) have learned some tough lessons and cool hacks:

- **Viruses be gone!** Always buy scions that have been certified as free from disease.
- **Pick the right tools.** Avoid scissor-style "bypass" shears, says UCD Professor Ali Almejdi. Buy sharp "anvil" shears that work by chopping. For the cleanest cut, make sure the blade's on top and the steel base is on the bottom. Get a true grafting knife made with carbon steel that's "flat ground," with the blade beveled on *one* side only, not both, for a cleaner cut.
- **If you can't match the cambium on both sides of the graft, just match one side and then wrap the graft.** That should be good enough.
- **Don't leave the grafting tape on forever; it can impede growth.** Remove it when a callus forms around the graft. Or open a wide rubber band so it's one long strip, and wrap it around the graft. The rubber will eventually deteriorate and fall off.
- **Keep your scions cool.** "Dormant scion wood — stems from pear, apple, peach, cherry, and other trees — is best stored between 30 and 38 degrees [Celsius]," notes Real. The steps to success can be found online at makezine.com/07/graft.

● **Graft strategically.** If you're smacking multiple grafts on a tree, think about placement. On his record-breaking citrus tree, Real grafted the most frost-resistant fruit at the top (mandarin oranges) and the least resistant at the bottom (limes and grapefruit). "The top level serves as a frost blanket for the citrus below," says Real.

By the same token, don't let a graft take over your tree. Graft vigorous scions on the northern side of the tree (less light means slower growth) and more mature scions on the southern side.

● **Graft the graft.** Trying to graft distantly related plants (like apples and pears) and failing? Find an intermediary plant that's closely related to both, in this case quince.

Hack the plant: A whip graft is a good choice if the rootstock (be it the trunk of a young tree or a major branch on an older tree) is about the same diameter as the scion you want to graft onto it. Whip grafts are strong and heal quickly. If you're new to grafting, start with apple or pear trees; they're simple to work with and forgiving of misaligned cambium.

First, cut off the top of the rootstock, leaving 6 to 12 inches. Remove any side shoots. For the scion, pick a stem about 9 inches long, cut just above a bud. The stem should be the same diameter as the rootstock, or slightly smaller. Make a 2-inch sloping cut at the end of the scion, and a matching cut at the top of the rootstock. On the cut surface of each, use your knife to create a little flap like a tongue. Then mate the scion and rootstock, fitting the flaps together. When the two cambium layers are kissing, wrap the graft tightly with tape, then apply a liberal amount of wound sealant all the way around the graft.

Attach a tag that notes the scion's species and the date of the graft. Keep a record in a ledger or on your computer, recording the rootstock, when the scion should bloom, the source of the scion, how well the graft took, how tasty the resulting fruit was, and so on.

MAKING THE HACK

Pollination



Tools of the trade: Tweezers, small clean paintbrush, magnifying glass, glassine bag

Rules of the road: Being the first on your block with a DaffoMelon would be cool, but don't hold your breath. Typically, you can cross plants of the same species to create a new variety. You can also make successful crosses between different species in the same genus, such as the raspberry (*Rubus idaeus*) and blackberry (*Rubus rosaceae*), which results in a loganberry. Rare, however, is a cross between plants from two different genera. Adjust your expectations accordingly.

As you might expect, crossbreeding is easiest with plants that boast big sex organs: clearly defined and separated stamens and pistils. Two obvious candidates would be daffodils and tulips, but get the MO on a plant's life cycle before you cross it with anything. You might have to wait several years before a flower appears. (Our reference of choice: Charles Welch's *Breeding New Plants and Flowers*.)



Hack the plant: To get the 411 on the mating dance, we spent the day with Todd Perkins, a flower breeder at Goldsmith Seeds. His recommendation? First, work with a plant that normally has prominent organs (such as the petunia), so you can easily control the pollination. (If you don't, you'll definitely need that magnifying glass.) If you have the time, grow several varieties of the plant and let them cross naturally. Select the offspring you like, and grow their seeds. Repeat this process until you have two plants with the traits you want to meld.

Using tweezers, emasculate (ouch) the target flower by removing its stamen. (The stamen often look like tiny stalks that ring the center of the flower; the pollen-bearing tip is called the anther.) This will prevent the plant from pollinating itself.

From the source flower, collect pollen from the tip of the stamen with a small paintbrush. Trot over to the target flower, locate its stigma (it's often a tall tube in the center of the flower, which leads to the plant's ovaries) and brush the pollen on it. Tag the flower that's been pollinated, noting date and which plant/flower was the pollen source. Finally, slap a

1. Remove the stamens to prevent the flower from self-pollinating.

2. Gather pollen from the donating flower with a small paintbrush and bring it to the target flower.

3. Brush pollen against the flower's stigma. The pollen will migrate down the tube, fertilize the flower's eggs, and start making seeds.

chastity belt — a glassine bag — over the flower to prevent pollination from other sources.

In less than 24 hours, fertilization will occur and the flower will wilt. (Why? First, to prevent further pollination, and second, to force the plant to marshal its resources for reproduction.) In as little as four weeks, you'll get seeds. Plant the seeds and you'll get your hybrid plant, right?

Not exactly. Thanks to the nature of sexual reproduction and recombination, you'll get plants exhibiting a huge mix of characteristics from their grandparents.

One solution? From this first batch of plants, pick the ones that are closest to your ideal, and mate

them with the best parent. (A practice known as *backcrossing*.) This will produce seedlings that contain 75% of the parent's genes. Pick the plants from this next batch and pollinate each plant with its own pollen. This should effectively lock in the characteristics you want. The seeds from these plants should be nearly identical and generate the hybrid you want.

The big exception? This only works if you're selecting for *simply inherited* traits — those tied to a single gene. With traits controlled by multiple genes, the plants you grow from seed will still be all over the map.

The second solution? Once you've got a plant that's close to your ideal, clone it. Take cuttings from the plant, place them in the appropriate medium (such as peat and perlite), add water and perhaps a rooting hormone, and soon shoots and roots will develop. Plant 'em and voilà — up comes your hybrid. "This is the lockbox," says Goldsmith's Perkins. "It's the one sure way to preserve the hybrid that you've created." (For more on cuttings, see makezine.com/go/cuttings.)

THEM THAT PLANTS ...

As you've probably guessed, this article just scratches the soil on the topic of plant hacking. There are lots of different techniques and lots of variation among plants. (You'll discover, for example, that some plants stubbornly resist crossbreeding and that anatomy varies wildly from species to species.) And, of course, there are many related issues to explore at length, from plant care and feeding to propagation.

The biggest challenge, however, is mental.

"There's a fine line between gardening and madness," says Andy Mariani of Andy's Orchard in Morgan Hill, Calif. But, as obsessions go, plant hacking is one of the better ones.

Special thanks to Dr. Tom Gradziel and Dr. Ali Almehdi of UC Davis; Todd Perkins of Goldsmith Seeds; Andy Mariani of Andy's Orchard; Dr. Carol M. Stiff of Kitchen Culture Kits; and Lisa Stapleton of the California Rare Fruit Growers association.

Robert Luhn is a technology and science writer based in El Cerrito, Calif., who spends his free time raising unattractive plants.

TIPS, TRICKS, AND TRAPS

● **Just starting out?** Limit yourself to one or two projects. Good starter veggies and fruit include tomatoes, squash, and melons. Good starter flowers include geraniums, fuchsias, and petunias.

● **Pollen has a limited shelf life.** You've got 24 to 48 hours, tops. So check the donating flower as soon as it opens. With many plants, fresh pollen is soft, loose, and fluffy, and comes off the anther easily.

● **Get Mendelian.** "This isn't for the casual gardener," says Andy Mariani. "To juggle the recessive and dominant traits, you must have an elementary understanding of genetics." Start with the books listed in the What to Read section below.

● **Pick the right parents.** Closely examine the two plants you want to cross. Are they robust, superior specimens, from buds to color to flowering? Only pick the best of the best.

● **Nip it in the bud:** Stop self-pollination at all costs. Gently open the flower while it's still a bud and remove the stamens. Then cover it for a day or two, until the stigma is ready to take the pollen.

● **When it comes to sex, timing is everything.** The pollen from the source flower must be fresh and the stigma in the receiving flower must be ready. How can you tell? This varies by species, but in some flowers, the stigma grows tall and splits — a sure sign it's ready for pollen. In others, the stigma becomes sticky and glistens (the mucus captures any pollen blowin' in the wind or dropped by a passing bee). If the stigma is dry, the moment is gone. **NOTE:** Some pollen is designed to be sticky, so bees will carry it off.

WHAT TO READ

Breeding New Plants and Flowers, by Charles W. Welch (Crowood, 2002)

Breed Your Own Vegetable Varieties: The Gardener's and Farmer's Guide to Plant Breeding and Seed Saving, by Carol Deppe (Chelsea Green, 2000)

Plant Propagation, The American Horticultural Society, Alan Toogood, editor in chief (DK, 1999)