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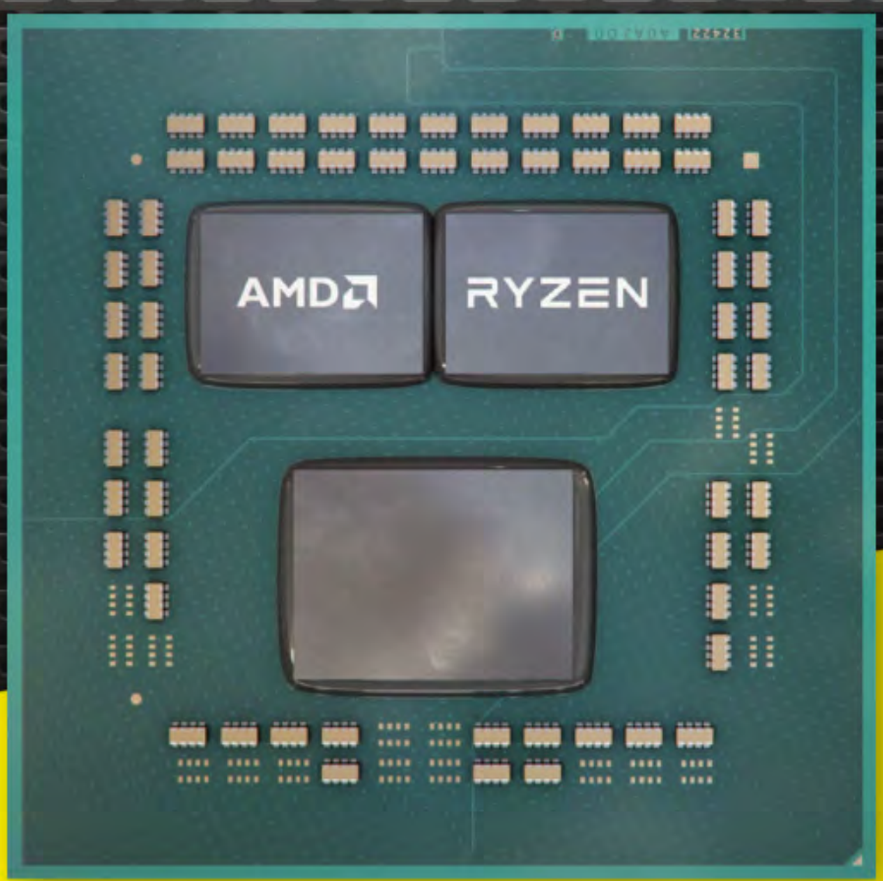
JULY 2019

FROM IDG

Ryzen 9 3950X



A 16-CORE CHALLENGE TO INTEL'S GAMING DOMINANCE


I am very sensitive to lights and sounds
Jacob Sanchez
Diagnosed with autism
Ad Council
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AUTISM SPEAKS

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CONTACT

PHONE 415/243-0500; **FAX** 415/442-1891

MAIL Editorial: 501 Second Street #600, San Francisco, CA 94107

STAFF ADDRESS To contact any *PCWorld* staff member, simply format the address as follows: *firstname_lastname@idg.com*

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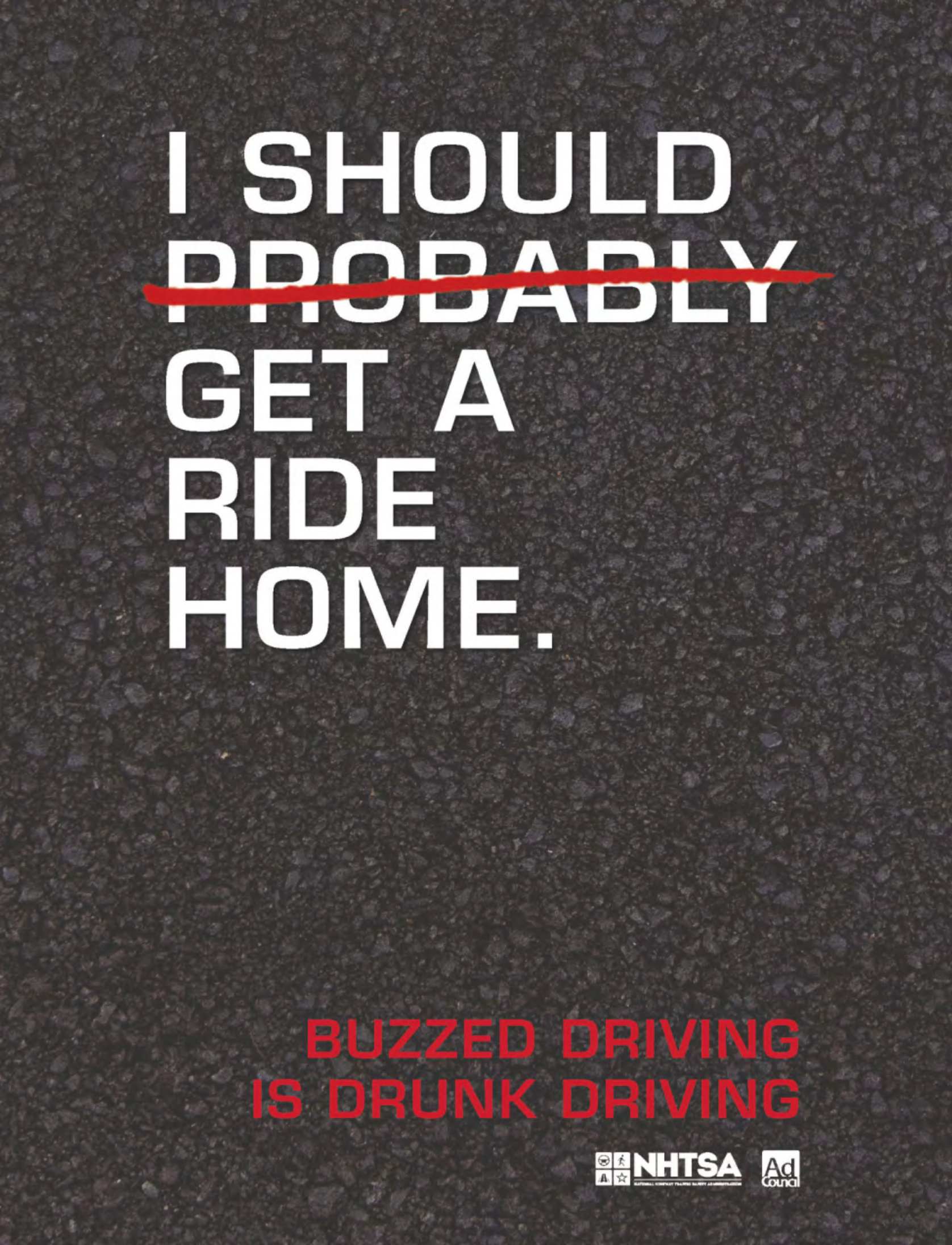
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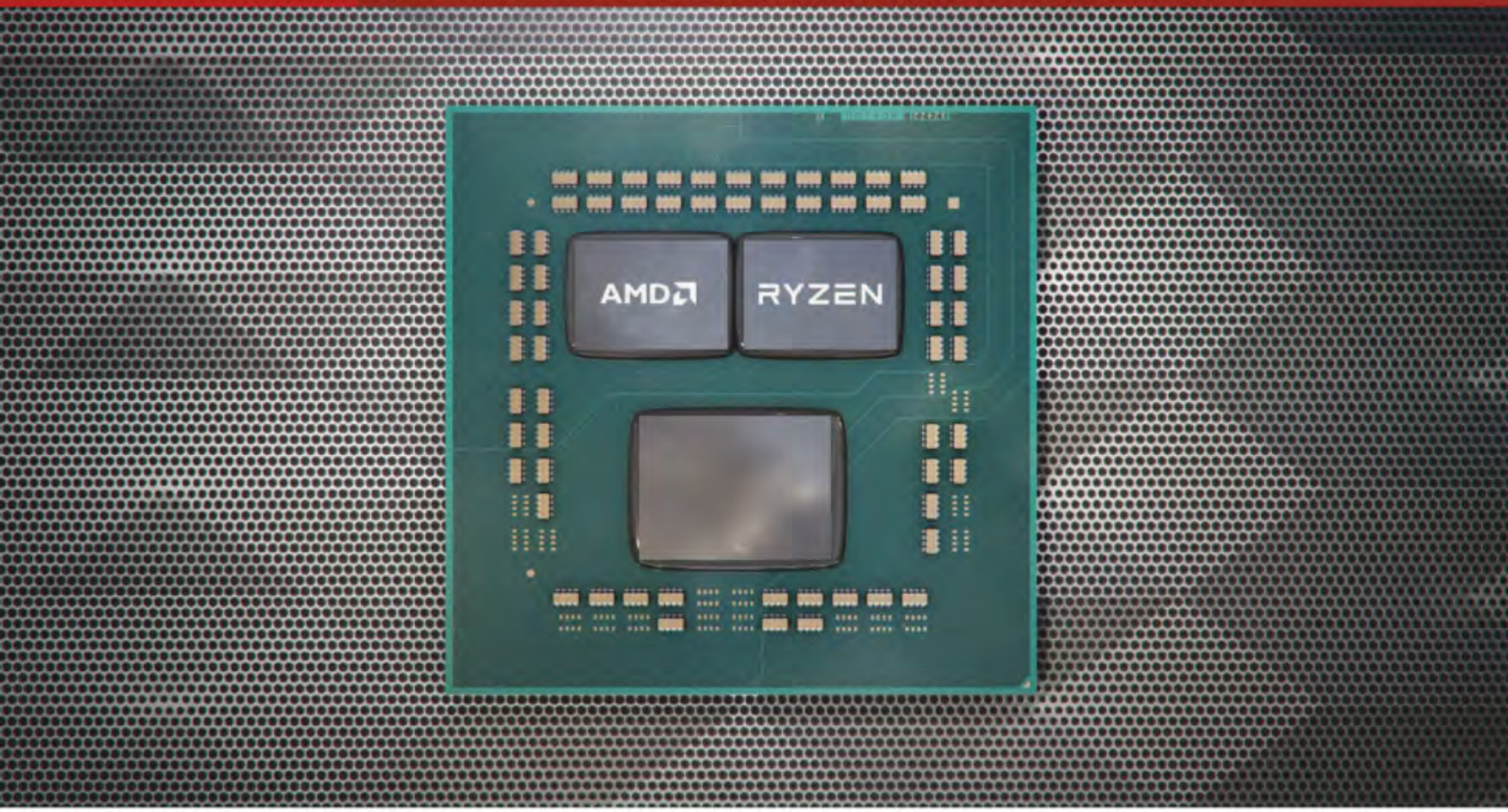


AMD's Ryzen 9 3950X is a 16-core CPU aiming to topple Intel's gaming dominance

Will AMD's 16 cores of goodness erase Intel's gaming advantage? Only tests will tell.

BY GORDON MAH UNG

With the debut of AMD's 16-core Ryzen 9 3950X, Intel's slim lead in gaming CPUs could disappear. Announced recently by AMD CEO Lisa Su at her keynote at E3, the company also claims that its new stack of 7nm-based Ryzen 3000 chips are competitive with Intel's higher-clocked CPUs in games, and dominant in multi-tasking chores.

The big news, of course, was the long-awaited, much-whispered Ryzen 9 3950X. During her keynote, Su said the CPU, which will be available in September, features a boost clock of 4.7GHz with a base clock of 3.5GHz. The chip will sell for $749.

Besides a massive cache of 72MB, not much else was said about the Ryzen 9 3950X.

IMAGE: AMD

It's finally here! AMD's Ryzen 9 3950X features 16-cores and 72MB of cache, and is built on a 7nm process.

Here are the chips AMD will put up for sale on July 7.

But its arrival means that AMD has fully fleshed out its lineup that will take on Intel's 9th-gen chips.

WHAT MAKES RYZEN 3000 SO MUCH FASTER?

Ryzen 3000's performance increases don't seem to come from just one single aspect, but an accumulation of changes between the Ryzen 3000 series and older Ryzen 2000 chips.

Obviously, one of the big advances is the process shrink from Ryzen 2000's 12nm to Ryzen 3000's 7nm. AMD officials said process shrinks typically increase wire resistance, as the wires literally get smaller. But the company has successfully gone against that and actually increased clock frequencies generation to generation.

The smaller process yields sizable power efficiency increases, too. For example, AMD said a Ryzen 7 3700X offers 75 percent more performance than a Ryzen 2700X in Cinebench R20 multi-threaded tests. During that test, the Ryzen 7 3700X consumes 135 watts at the wall, while the Ryzen 7 2700X demands 195 watts.

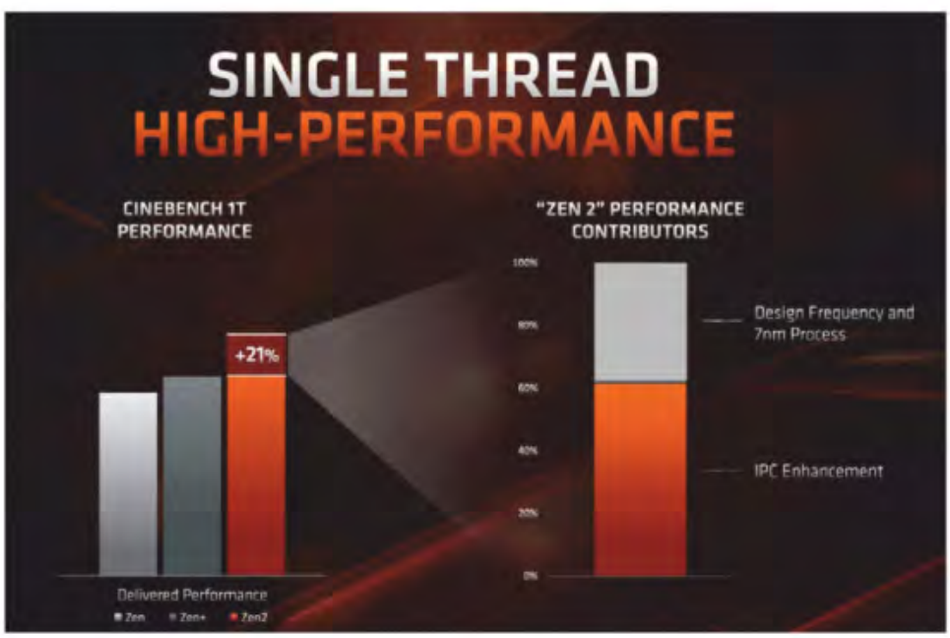
When companies move to a completely new process technology, they usually keep other aspects of the chips intact. In the move from 12nm to 7nm process, however, AMD took the additional step of redesigning the x86

AMD said despite the difficulty of increasing clock speeds as you shrink chips, it has successfully done so for its 7nm chips.

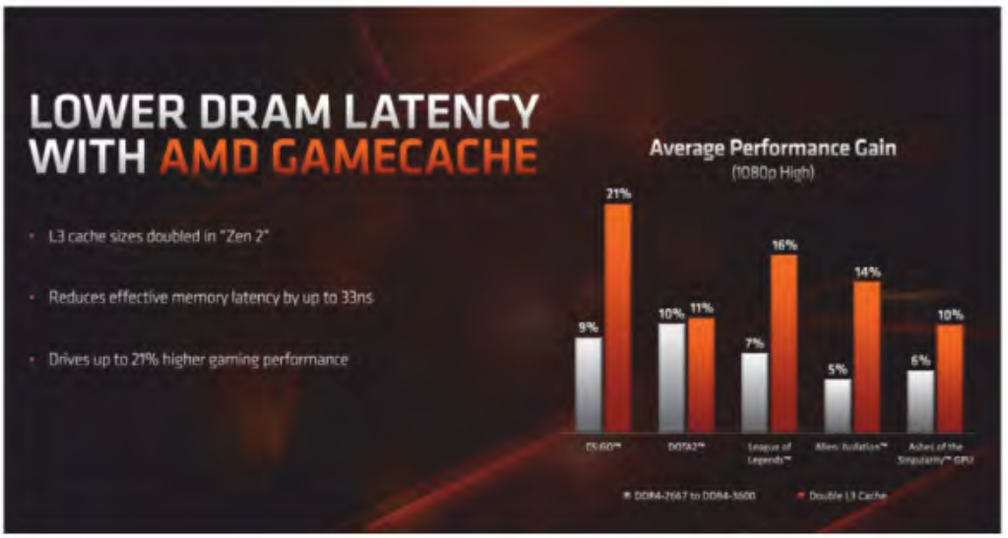
core's innards, adding a new front-end with improved branch predictor, better instruction pre-fetching, and larger caches. The 7nm Zen 2 cores basically feature double the floating point performance over 12nm Zen+ cores, yielding a 25-percent increase in performance for the same power as the Zen+ chip.

AMD has also worked hard to address one of the issues it's had with memory latency. By moving from DDR4/2667 to DDR4/3600, many games yield up to double-digit performance bumps.

The other half of that comes from the CPU's cache. With Ryzen 3000 chips, the L3 cache basically gets doubled in size. For example, the 12-core Ryzen 9 3900X features



AMD said the Zen 2 cores yield a 21 percent performance increase over the Zen+ cores with roughly 40 percent of that coming from the process and 60 percent of it from IPC improvements.

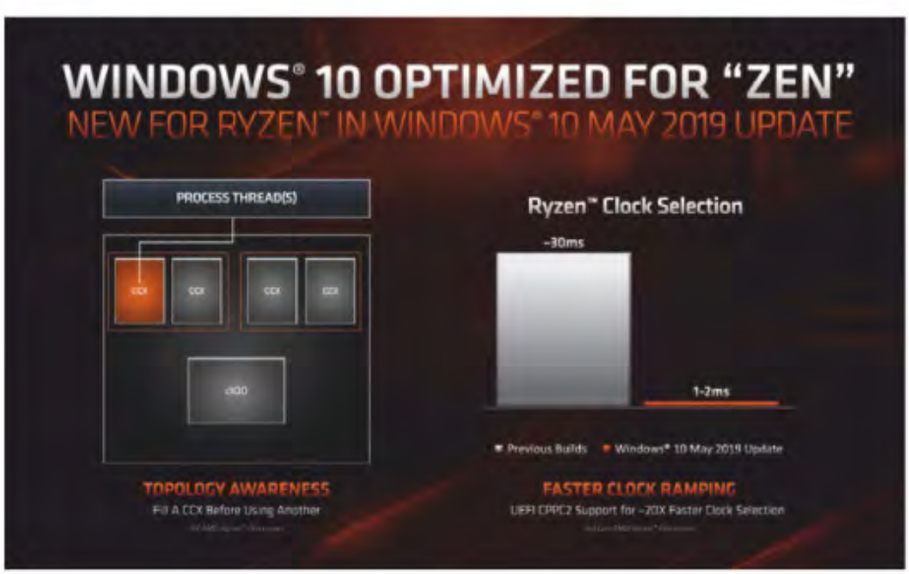


a whopping 70MB of cache. That all adds up to a sizeable boost in gaming performance, especially at lower resolutions, AMD said.

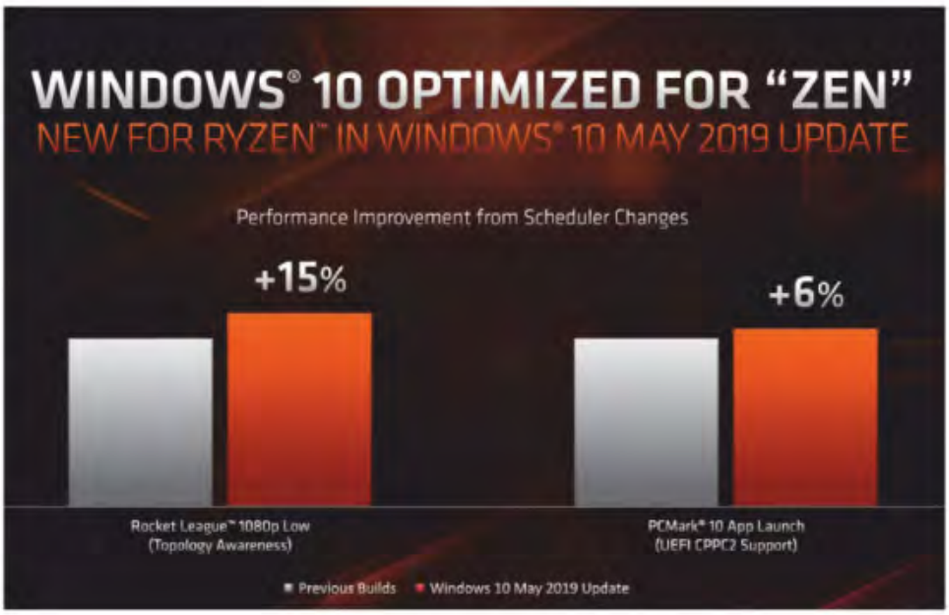
MAYBE THE WINDOWS WAS BROKEN AFTER ALL?

One other advance for Ryzen 3000 (and perhaps all Ryzen chips) are new "optimizations" from Microsoft. When the original Ryzen was released, some of the performance, especially in gaming, was baffling. It didn't take long for many to suspect that Windows 10 just didn't know what to do with the multi-die package of the chip—specifically, how Windows 10's scheduler dispatched work to the CPU cores. Many believed Windows 10 was willy-nilly sending work to cores on a different chip rather than the same chip—even if a CPU core was free on the same chip. (At the time, AMD actually came out and absolved (go.pcworld.com/bust) Microsoft Windows 10 of any blame. But, frankly, it never rang true to us.)

As of the Windows 10 May 2019 Update, AMD said optimizations to the operating system will dispatch work to adjacent cores on the same die first, which will greatly reduce latency. AMD also said the May 2019 Update will bring faster clock ramping in its chips. With previous builds of Windows,



Windows 10 "optimizations" sound an awful lot like a fixed scheduler.



A new "optimized" scheduler offers up to a 15-percent improvement in *Rocket League*, while faster clock ramping can lead to a 6-percent improvement in PCMark 10's App launch test.

AMD said it could take around 30 milliseconds for the CPU to ramp up to higher frequencies. As of the update (and with a new chipset driver) it'll take just 1 to 2 milliseconds for the chip to reach its top speed. These fixes give some games a boost of 15 percent, while the faster clock ramping can yield 6-percent improvements.

RYZEN 3000: FASTER IN GAMING

So what does this all mean? Gaming parity with Intel's chips at last, AMD claims. At Computex AMD actually hinted at what the new chip could do (go.pcworld.com/hint), but for E3, it's breaking out the gourmet stuff with gaming bumps at 1080p resolution competitive with Intel's chips.

Yes, you heard that right: AMD claims gaming at 1080p is competitive with Intel. The resolution is important, because at the original Ryzen launch (go.pcworld.com/oryz) fans complained that testing at a "low" resolution of 1080p was unrealistic, unfair, and biased toward Intel. This was argued despite the fact that 1080p gaming is the most popular resolution among PC gamers today.

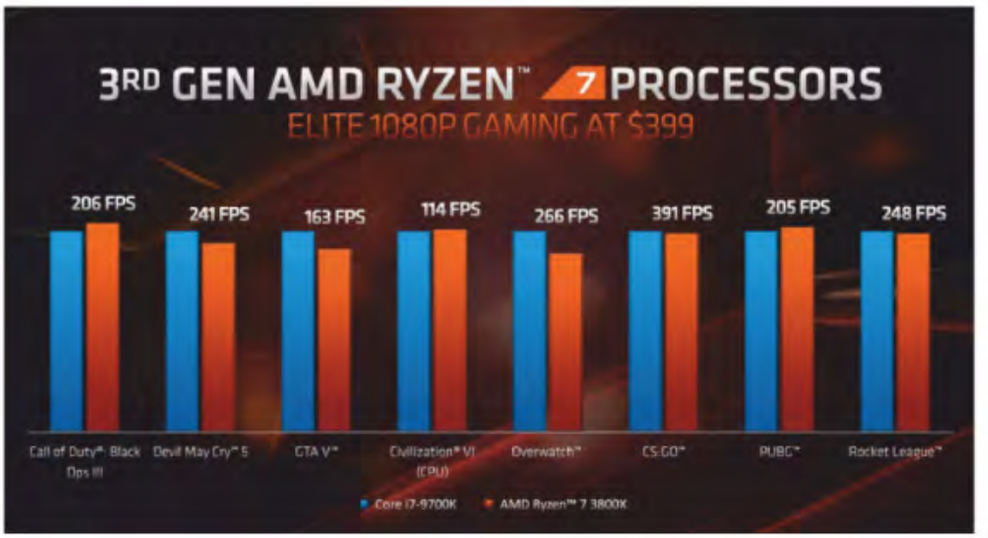
That didn't change much with the Ryzen 7 2700X either. Gaming, especially at 1080p resolutions, has long favored Intel's higher-clocked Core i7 and Core i9 chips by 15 to 20 percent generally.

If AMD's claims are to be believed, that edge is now obliterated. Citing popular games *Call of Duty Black Ops, GTA V, Counter Strike: Global Operations, PUBG* and *Rocket League,* AMD said the $399 Ryzen 7 3800X is basically dead even with the $409 Core i7-9700K.

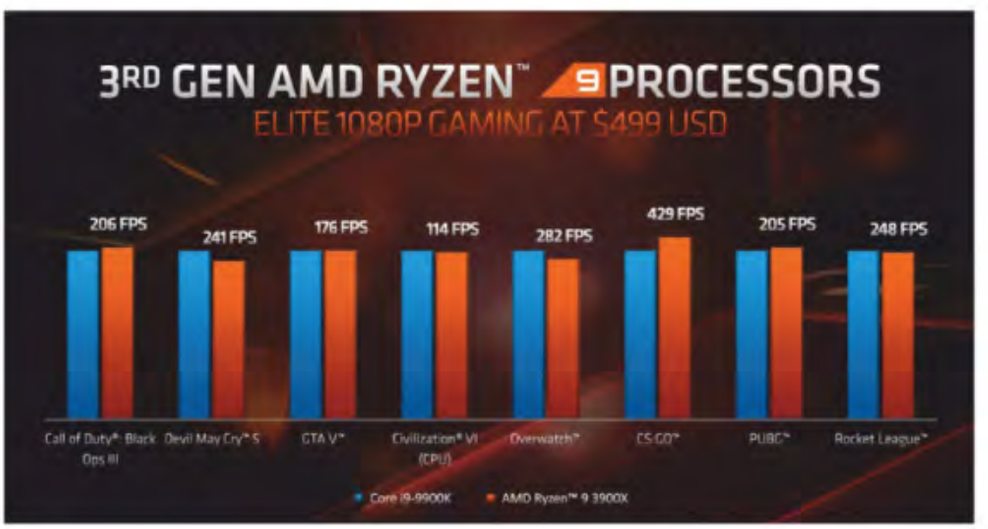
And yes, the mighty 8-core Core i9-9900K, which can boost up to 5GHz, is dead even with the Ryzen 9 3900X at 1080p resolution, as you can see from the

performance testing AMD has done on the chips.

These gaming claims are, of course, to be taken with a grain of salt, because no one has tested them independently. We have a few outstanding questions, but the main one is whether the Core i7 and Core i9 were tested with Multi-Core Enhancement turned on. MCE on Intel chips are themselves somewhat controversial. Some feel it's "cheating" for Intel, because it automatically overclocks the chip beyond the stock guidelines.



AMD claims it can stand tall with Intel's chips in gaming, even at 1080p.



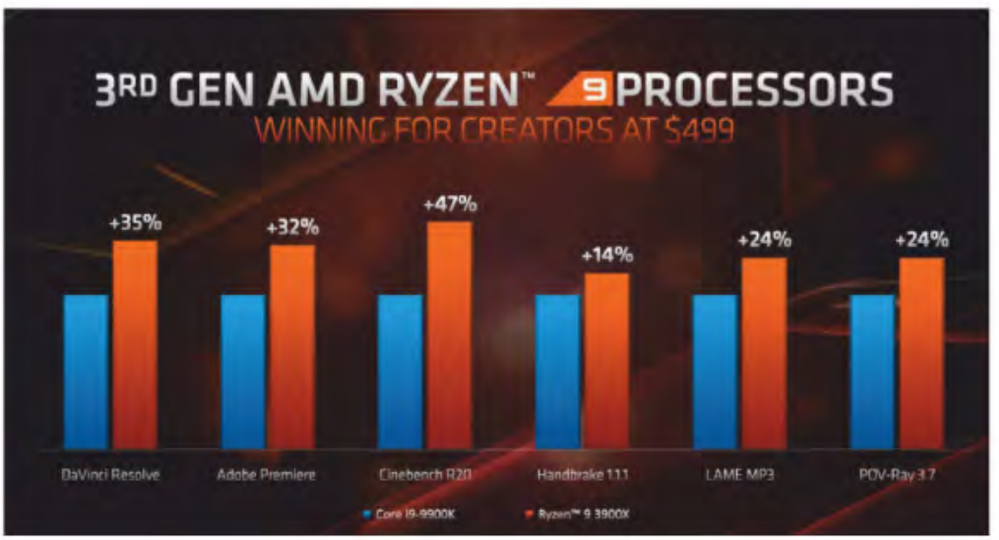
If AMD's numbers are to be believed, the new Ryzen 3000 just took away the Core i9's last defense.

Our own take in our Core i9-9900K (go.pcworld.com/i900) review is more nuanced. Because MCE usually comes set to "auto" out of the box on most Intel Z390 motherboards, we test it set to off, on, and auto. All three produce different results depending on the motherboard.

With the Ryzen 7 2700X, AMD opted for MCE Off. The company confirmed it did the same with these benchmarks.

IS AMD CHEATING?!

If you're thinking AMD may be cheating by turning off MCE to make its chips look better, here's something to chew on.



It's crazy that we're actually bored by how much faster Ryzen is over Core chips in multi-threaded performance.

Remember the "Optimized" Windows scheduler fix that bumped *Rocket League*'s performance by 15 percent?

All of the performance testing you're seeing here, AMD officials tell us, are done without the updated Windows scheduler in place. AMD also tells us it didn't install the latest security mitigation for Intel's chips either.

So while MCE Auto would likely give the Intel chip more performance, the Ryzen 3000 probably would also see a bump in some games from the latest Windows 10 scheduler.

WHAT ABOUT CONTENT CREATION APPLICATIONS?

One thing we didn't talk about is the content creation performance of the new Ryzen 3000 chips. That's because, frankly, it's boring news. We should all know by now that a 12-core Ryzen 9 3900X is going to outpace an 8-core Core i9-9900K. We will run one benchmark chart from AMD to humor you, but from Ryzen 9 to Ryzen 7 and Ryzen 5, AMD has both core- and thread-count advantages over Intel's Core i9, Core i7, and Core i5. In applications that really use all of those threads and cores, AMD wins 9 out of 10 times. So yawn.

What this comes down to, and why it now makes sense that AMD launched its Ryzen chips at E3 instead of Computex, is that the new chips may very well remove the only advantage Intel may have left: gaming.

Coming on the heel's of Intel's brazen challenge (go.pcworld.com/chal) to AMD to stop showing only multi-threaded benchmarks and use "real-world gaming," the gaming performance of these chips is really the only thing that matters here at E3.

Obviously, you should wait for independent reviews to see if AMD's claims are true, but the battle for the "best gaming CPU" (go.pcworld.com/gmsp) and the crown is going to get really hot, really soon.

AMD's new Ryzen 3000 APUs give budget gamers an affordable taste of Radeon Vega

AMD's new Ryzen 3000 APUs don't step it up the way the new Ryzen 3000 CPUs do, but they look to still be decent updates. **BY GORDON MAH UNG**

If you're on a Top Ramen diet, the last thing you're probably jazzed for is AMD's new $750 16-core Ryzen 9 3950X or its $450 Radeon 5700 XT (go.pcworld.com/navi) graphics card. But AMD buried some good news for budget gamers among its massive CPU, GPU, and motherboard PCIe 4.0 announcement blitz at E3 2019: A pair of affordable new Ryzen 3000-series APUs.

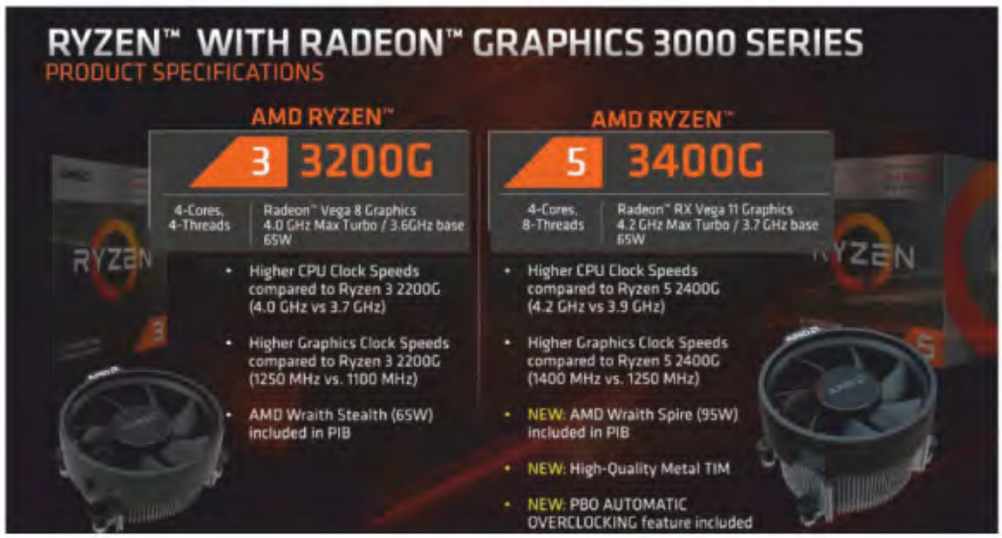
AMD's APUs blend the company's Ryzen processing cores with Radeon Vega graphics on a single ready-to-game chip.

The Ryzen 3 3200G will feature a quad-core chip running with a 4GHz boost and 3.6GHz base speeds. For graphics, it will

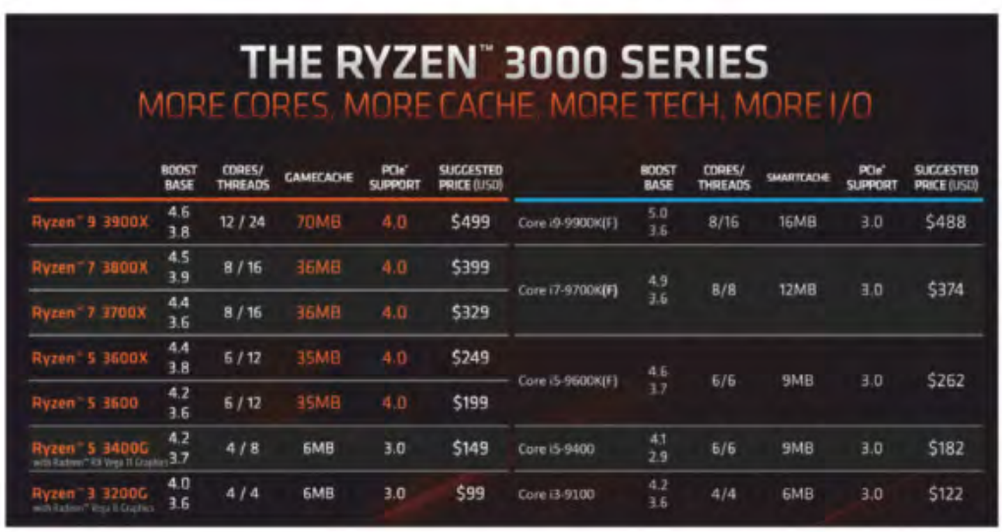
IMAGE: GORDON MAH UNG

feature Radeon Vega 8 GPU cores running at 1,250MHz. The new APU will come with a Wraith Stealth cooler.

Compared to the previous Ryzen 3 2200G, the newer Ryzen 3200G (go.pcworld.com/ryz3) will run about 300MHz faster on the CPU side and about 150MHz faster on the GPU side. Budget gamers will be especially pleased by the price though: AMD will still charge $99 for the APU.



AMD's newest APU's are the same price but slightly faster.



	BOOST BASE	CORES/ THREADS	GAMECACHE	PCIe® SUPPORT	SUGGESTED PRICE (USD)
Ryzen™ 9 3900X	4.6 3.8	12 / 24	70MB	4.0	$499
Ryzen™ 7 3800X	4.5 3.9	8 / 16	36MB	4.0	$399
Ryzen™ 7 3700X	4.4 3.6	8 / 16	36MB	4.0	$329
Ryzen™ 5 3600X	4.4 3.8	6 / 12	35MB	4.0	$249
Ryzen™ 5 3600	4.2 3.6	6 / 12	35MB	4.0	$199
Ryzen™ 5 3400G with Radeon™ RX Vega 11 Graphics	4.2 3.7	4 / 8	6MB	3.0	$149
Ryzen™ 3 3200G with Radeon™ Vega 8 Graphics	4.0 3.6	4 / 4	6MB	3.0	$99

	BOOST BASE	CORES/ THREADS	SMARTCACHE	PCIe® SUPPORT	SUGGESTED PRICE (USD)
Core i9-9900K(F)	5.0 3.6	8/16	16MB	3.0	$488
Core i7-9700K(F)	4.9 3.6	8/8	12MB	3.0	$374
Core i5-9600K(F)	4.6 3.7	6/6	9MB	3.0	$262
Core i5-9400	4.1 2.9	6/6	9MB	3.0	$182
Core i3-9100	4.2 3.6	4/4	6MB	3.0	$122

The Ryzen 3 3200G and Ryzen 5 3400G fill out AMD's lineup of new CPUs but just don't think you get the latest process inside.

The $149 Ryzen 5 3400G justifies its higher price by outfitting its quad-core CPU with simultaneous multi-threading. It'll run at 4.2GHz on boost (about 300MHz faster than the previous Ryzen 5 2400G) and have a base clock of 3.7GHz. The graphics are faster too, upgrading to Radeon RX Vega 11 graphics that run at slightly higher clocks than its predecessor (1,400MHz instead of 1,250MHz).

The Ryzen 5 3400G will now ship with a beefier Wraith Spire cooler rated for 95 watts. AMD also said it has replaced using a composite "paste" like thermal interface material with a "high-quality metal" one too. Officials told us it's basically the equal of a indium gallium solder on the new chip. That

should come in handy if you plan on overclocking the chip.

NEW NAME, OLDER CORE DESIGN

One thing to keep in mind as you review that menu of AMD CPUs above: Even though the Ryzen 3 3200G and Ryzen 5 3400G carry "3000-series" model names, they're not actually AMD's new leading edge 7nm Zen 2 cores. That cutting-edge technology is reserved for the new Ryzen 3000-series CPUs alone.

Instead, both Ryzen 3000 APUs are actually based on AMD's prior-gen 12nm cores, aka Zen+, despite their model numbers.

Before you mount your outrage horse, this isn't actually new for AMD. AMD's previous Ryzen 2000 APUs were also introduced with AMD's original 14nm Zen cores just before the company's newer 12nm-based Zen+ cores were introduced, so it's not a new naming convention. The core technology in AMD's Ryzen APUs always lag a generation behind the much pricier Ryzen CPUs.

And yes, please do pound your fist on the table and demand an expensive new 7nm process in a $99 chip, and then realize you actually said it out loud.

INTEL STEPS UP THE COMPETITION

What might be more of a problem for AMD is how well the Ryzen 3000 APUs handle their Intel equivalents. The original Ryzen APUs went against far weaker 7th-gen Intel CPUs because Intel's newer 8th-gen chips would only work on motherboards costing $120 or more.

With this launch, Intel's 9th-gen chips can slot into motherboards at a more reasonable $55. So now, AMD's quad-core APUs will battle far more potent chips instead of ho-hum dual-core CPUs.

While a Ryzen 3 3200G is probably going to face a back and forth battle with a Core i3-9100 in computing tasks, the quad-core (with SMT) Ryzen 5 3400G will have to duke it out against a six-core Core i5-9400.

WE SEE WHAT YOU DID THERE, AMD...

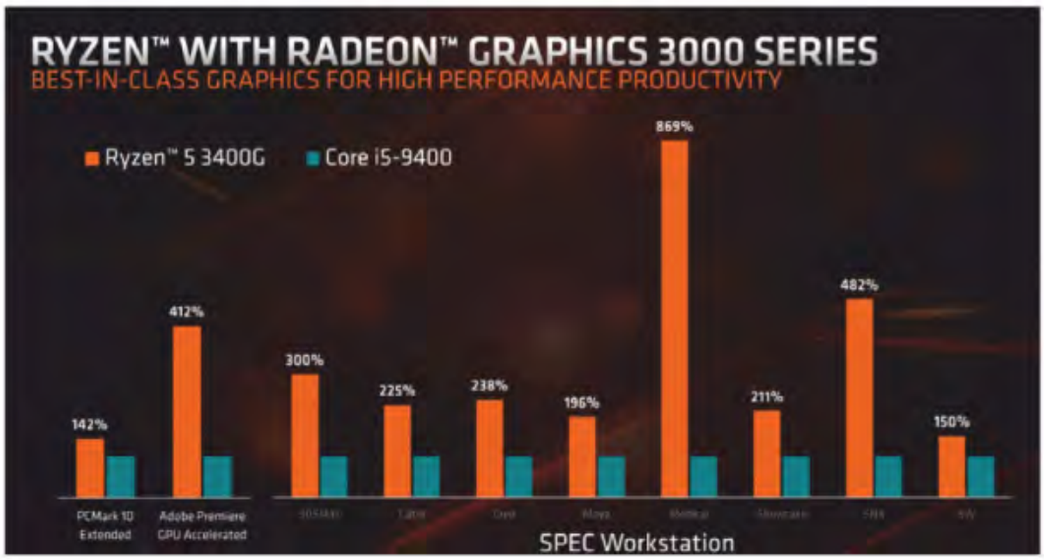
We suspect that's why AMD didn't show off benchmark charts in tasks that would load up the CPU cores. Instead, we saw benchmarks using PCMark 10 Extended, Adobe Premiere GPU Accelerated, and SPECviewperf.

SPECviewperf is a graphics-intensive professional benchmark. And, well, the name "Adobe Premiere GPU Accelerated" pretty much tells you what that test means too. PCMark 10 Extended can lean either way but with AMD failing to show Cinebench, Blender, or other multi-core rendering tests we can surmise it probably means the new APUs are neck-and-neck with Intel's chips there—or possibly slower.

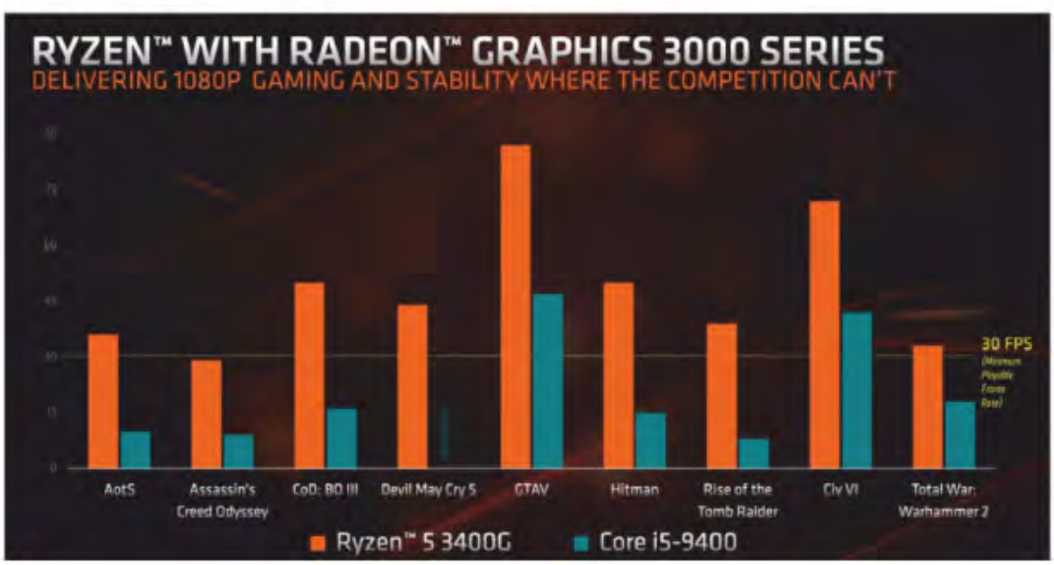
But it seems like the true strength of AMD's Ryzen APUs—their integrated Radeon Vega graphics—remains a win. AMD released

gaming figures that show fair performance for the Ryzen 5 3400G when gaming at 1080p resolution.

Intel's Core i5-9400 with its integrated UHD630 graphics hasn't ever hung with AMD's graphics cores, and it looks like the Ryzen 3000 APUs hit even harder. This might very well change when Intel's new Gen11 graphics hit the street in its upcoming Ice Lake CPUs (go.pcworld.com/10th), but when those graphics cores even make it into a budget desktop part from Intel is anyone's guess.



AMD released benchmarks that most cynical nerds will say were picked to stress its strength in graphics and deemphasize its x86 performance. Good marketing AMD, but yeah, we see what you did there.



Not breaking news: Radeon Vega 11 stomps Intel's UHD630 still.

In the end, the Ryzen APU updates are welcome as there are plenty of worthy improvements in AMD's Zen+ cores, but these chips don't look to bring the buzz factor that the big 16-core and 12-core Ryzen 9 chips bring.

They'll likely still be very solid budget gaming chips, especially for people who can't invest in a discrete graphics card (go.pcworld.com/dcrt).

Next-gen Xbox 'Project Scarlett' console packs Ryzen, Radeon Navi, SSDs, and ray-tracing

Here's what you need to know about the next-gen Xbox console and Project xCloud.

BY HAYDEN DINGMAN

Six years after the infamously terrible reveal of the Xbox One, Microsoft has somewhat redeemed itself. At Microsoft's E3 2019 press conference, Phil Spencer detailed the plans for its upcoming next-gen Xbox console, "Project Scarlett," a traditional high-end box that will live alongside Microsoft's "Project xCloud" streaming service. Project xCloud is due later this year, while you'll need to wait until holiday 2020 for Scarlett, as expected.

Let's break it down. If you're curious about the games revealed at Microsoft's showcase (go.pcworld.com/mse3), we split those out into a separate article, complete with trailers for all the major announcements.

PROJECT SCARLETT NEXT-GEN XBOX

"We believe a console should be for one thing: Gaming." That was Phil Spencer as

IMAGE: MICROSOFT

he started discussing the next-generation Xbox, a pointed change of direction for the company that wanted to be in all things entertainment when the Xbox One launched six years ago. No scope creep here, no mixed messages. Project Scarlett is about games.

And the big leap forward is…SSDs. Just like Sony's next-gen PlayStation 5 (go.pcworld.com/sps5), it seems Microsoft's putting a huge emphasis on the SSD, instead of the old, slow hard drives in the Xbox One and PlayStation 4. The way they're pitching it to gamers is "No load times," which is obviously a huge benefit that we've had on PCs for quite a while now. It'll be neat to see the SSD become the baseline spec, though, moving forward, with developers hopefully designing around the SSD and seamless worlds in a way they couldn't when they were splitting the difference between console and PC hardware.

Microsoft didn't give us much in the way of hard specs, but the core of Scarlett is once again AMD-based, built off the Zen 2 and Navi CPU and GPU architectures, respectively, with blazing-fast GDDR6 memory. We were told it's four times as powerful as the Xbox One X, which already had the capabilities of a GeForce GTX 1060—pretty damned impressive for a console. And yes, it will support adaptive sync variable refresh rate technology as well as hardware-accelerated ray tracing.

The rest is more meaningless. Microsoft touted the capability for both 8K resolutions and 120 frames per second framerates, but it's doubtful many developers will take advantage of either of those. Presumably media will output at 8K, but few games will hit that resolution natively. And developers are notoriously reticent to take advantage of higher frame rates on consoles, even when they have the option. The Xbox One outputs at 60 frames per second, but most developers opt for 30 frames per second with better graphics. I expect Project Scarlett

to follow suit.

And as you might expect, *Halo Infinite* is confirmed as one of the first Project Scarlett titles. We got a decently long trailer during E3, showing off the end of humanity's battle, the fall of Master Chief, and other very ominous imagery. It should make for a great launch title, especially if it's as different gameplay-wise from *Halo 5* as we've heard.

Microsft confirmed *Halo Infinite* as one of the first Project Scarlet titles.

PROJECT XCLOUD

You won't need to wait until next-generation hardware for a taste of the next generation though. Microsoft also announced that Project xCloud, its game-streaming service, will arrive in October—ahead of Google's Stadia (go.pcworld.com/stad).

That's…basically it though. Console-based streaming was listed as a tentpole of Microsoft's new strategy, but we didn't get any details on connection speeds, pricing, game compatibility, or any of the details you might want if you were waiting to make a choice between the streaming platforms of the future.

Phil Spencer started with "Two months ago, we connected all Xbox developers to Project xCloud," which certainly sounds promising. We're also due to get hands-on time with the service here at E3, so perhaps we'll be able to wrangle more details in the coming days. For now though, all we can say is "It's coming, and Microsoft's definitely invested."

BOTTOM LINE

This is basically a teaser for next year's press conference though. Neither Sony nor Microsoft want to play their hand too early, so while both have given us basic specs—very similar-sounding specs, I might add—it'll be E3 2020 where we hear about pricing, hard release dates, and launch lineups. I'd expect many of the games, including *Cyberpunk 2077* and *Dying Light 2*, plus From Software's newly announced *Elden Ring*, to either straddle the console generation changeover or be Scarlett exclusives, but that's probably news for next year as well.

NSA warns that 'BlueKeep' vulnerability in Windows XP and 7 is especially dangerous

Microsoft has issued a BlueKeep patch for Windows 7, and in an unusual step, for Windows XP as well. **BY MARK HACHMAN**

The National Security Agency is warning users that a recent vulnerability affecting Windows 7 and Windows XP systems is potentially "wormable," meaning that it could be exploited and weaponized by malware.

Microsoft issued an alert in mid-May about a Remote Code Execution vulnerability, known as CVE-2019-0708 (go.pcworld.com/cve2), that can affect Windows 7, Windows XP, Windows 2003, Windows Server 2008 R2, and Windows Server 2008. Since then, the vulnerability has been nicknamed "BlueKeep." Microsoft issued a BlueKeep

IMAGE: LEO WOLFERT / GETTY IMAGES

patch for Windows 7 (go.pcworld.com/ptw7), and another BlueKeep patch for Windows XP (go.pcworld.com/ptxp). Microsoft strongly urges users to patch affected systems.

That's because code designed to exploit the vulnerability could spread pre-authentication and without any user interaction. These are prime breeding conditions for a worm similar to the spread of WannaCry, Microsoft warned (go.pcworld.com/worm). WannaCry took down millions of computers in 2017, using an unsophisticated yet pervasive attack (go.pcworld.com/wcry) that infected computers with ransomware.

The National Security Agency is concerned that this could happen again. "This is the type of vulnerability that malicious cyber actors frequently exploit through the use of software code that specifically targets the vulnerability," the NSA wrote (go.pcworld.com/nsaw). "For example, the vulnerability could be exploited to conduct denial of service attacks. It is likely only a matter of time before remote exploitation code is widely available for this vulnerability. The NSA is concerned that malicious cyber actors will use the vulnerability in ransomware and exploit kits containing other known exploits, increasing capabilities against other unpatched systems."

Though more than two weeks have elapsed since the vulnerability was discovered, Microsoft warned that cybercriminals often don't move that quickly. EternalBlue, the vulnerability that allowed WannaCry to take place, took a total of two months from the time that the vulnerability was discovered to the time it took to exploit it. "Despite having nearly 60 days to patch their systems, many customers had not," Microsoft said (go.pcworld.com/rmnd).

Naturally, Microsoft is taking the opportunity to encourage customers to migrate from older operating systems to Microsoft's latest OS, Windows 10.

Naturally, Microsoft is taking the opportunity to encourage customers to migrate from older operating systems to Microsoft's latest OS, Windows 10. Though Microsoft took the unusual step of publishing a BlueKeep patch for Windows XP, Windows 7 ends its support lifespan (go.pcworld.com/wend) this coming January.

"Customers running Windows 8 and Windows 10 are not affected by this vulnerability, and it is no coincidence that later versions of Windows are unaffected," Microsoft wrote. "Microsoft invests heavily in strengthening the security of its products, often through major architectural improvements that are not possible to backport to earlier versions of Windows."

We ran Quake II RTX on a GeForce RTX 2080 Ti card, and here's how fast it was

Nvidia's remastered Quake II RTX is the first fully path-traced video game, and you can have it for free. **BY GORDON MAH UNG**

You are now finally able to get Nvidia's remastered *Quake II RTX* version for free (go.pcworld.com/qkII). And if you're wondering just how fast the game runs, we just found out in the oldest-school way possible.

First, to catch you up, Nvidia has taken iD's classic 1997-vintage shooter *Quake II* and lovingly updated it with a fully path-traced renderer. While you might dismiss that as "just another game with hybrid ray-tracing" support, this is much more than that. At this juncture of ray-tracing hardware performance, most games use ray tracing sparingly and

VIDEO: **WE RAN QUAKE II RTX ON A GEFORCE RTX 2080 TI CARD**
Watch now at go.pcworld.com/bnm

IMAGE: NVIDIA

combine it with traditional raster techniques.

Nvidia's *Quake II RTX* remaster, however, renders everything (go.pcworld.com/rndr) by physically tracing light rays to create the scene. Such an undertaking with a modern game's complexity isn't possible, but 1997's *Quake II* puts it within reach.

Here's how you run a benchmark in *Quake II RTX* the way we did it in 1997.

Nvidia gave us a chance to play with a near-release version of *Quake II RTX* during Computex, so we decided to see how close in fidelity the RTX version was.

MEMORIES: GOING WAY, WAY BACK TO QUAKE II

When we talk about *Quake II*, we're talking old-school PC gaming, and old-school graphics. In 1997, Matrox was still in the game, AMD hadn't yet bought ATI, and even Nvidia's GeForce didn't exist yet (its card at the time was the Riva 128). In fact, dozens of graphics (go.pcworld.com/dozn) companies were still competing at the time.

As if to prove how the world is on a time loop, everyone was quaking in their boots in fear of Intel's upcoming discrete graphics card, the i740 using the AGP interface. The conventional wisdom among investors, technology analysts, and press was that Intel could do no wrong and would soon take over the discrete graphics market.

In 1997, though, PC gamers all wanted 3Dfx's Voodoo card (the Voodoo2 card would come out a year after *Quake II*).

HOW TO BENCHMARK QUAKE II RTX THE 1997 WAY

Only old-timers likely remember that *Quake II* had a built-in benchmark, which quickly became the gaming benchmark to measure graphics cards (the term GPU hadn't been coined yet). What's cool is Nvidia's remastering of *Quake II* includes the original timedemo from 1997.

To run it, install the game demo from Nvidia's website (go.pcworld.com/q2dm). The free version includes three levels but should be capable of running the *Quake II* built-in benchmark. Configure the game for the resolution and graphics quality settings

you want to test, then follow this key sequence:

1. Press the tilde key (~), typically at the top left corner (under the function-key row) on standard QWERTY keyboards.
2. Type **`timedemo 1`**
3. Type **`demo demo1`**

Those commands work in the *Quake RTX* version (which was built off of work [go.pcworld.com/crto] by Christoph Schied for his Q2VKPT project).

If you just want to see how your copy of *Quake II* runs today, you may have to type this instead:

1. **`timedemo 1`**
2. **`demomap demo1.dm2`**

For an alternative demo map, type **`demomap demo2.dm2`** instead.

Quake II will now run the short scene. Pressing the tilde key (~) again will show an average frame rate from the run.

Update: In the final demo released by Nvidia, the demo map seems to have been jettisoned, but you can still run the pre-canned benchmark by typing:

1. **`timedemo 1`**
2. **`demomap q2demo1.dm2`**

SO HOW FAST IS IT?

On a GeForce RTX 2080 Ti with a not-quite-final version of *Quake II RTX*, we saw roughly 97 fps at a resolution of 1920 x 1080, with visual quality set to high. For comparison, we saw about 419 fps in *Quake II*, set to 1920x1080 with 8x anisotropic filtering and multisampling turned off, using the OpenGL 3.2 renderer on a Core i7-9750H laptop with a GeForce GTX 1660 Ti GPU. We had to patch the Steam version first using the Yamagi patch.

If you're underwhelmed by 97 fps on a $1,200 GeForce RTX 2080 Ti card, remember what's going on here. The game is implementing a fully path-traced renderer and is computationally expensive to run. It's a technique that's really only been used in 3D movies to date, and fairly recently, too.

It also yields some beautiful effects. Glass windows and water in *Quake II RTX* obviously seem like night and day from the original version. So if you're going to snark about "only 97 fps" on a GeForce RTX 2080 Ti, know that a game session of *Quake II RTX* will easily render more ray-traced frames than a full-length animated movie, and in real time, too.

If you're planning on running *Quake II RTX*, you'll probably want to pair it with the Game Ready GeForce drivers too (available at go.pcworld.com/drvr).

IT'S LIKE 1997 ALL OVER AGAIN!

So rather than use this as an opportunity to create yet another hot take on the state of ray tracing in today's games and hardware, instead wind the clock back 22 years and crank up this gem of a game.

Google's play-anywhere Stadia game service gets a Founder's Edition bundle, pricing, and more

'Stadia' still sounds like a health insurance company, though. **BY HAYDEN DINGMAN**

Nearly a week before E3, Google, of all companies, kicked off festivities.

On June 6, Google detailed its Stadia streaming service (go.pcworld.com/stda), or at least gave us more details after a relatively info-light reveal at March's Game Developers Conference.

It's a bit complicated, though. Stadia Pro is the system everyone expected, a sort-of Netflix-for-games at $10 a month, with the top-tier technical package—4K, 60 frames per second streaming, and more—streamed seamlessly to any compatible device be it a laptop, desktop, Pixel 3 phone, or Chromecast.

Google will curate a selection of games for Stadia Pro, similar to Microsoft's Xbox Game Pass. And there were some great games Google mentioned in its presentation, including *Destiny 2*'s new Shadowkeep expansion—now with cross-platform save capabilities—and the long-awaited announcement of a *Baldur's Gate III* (go.pcworld.com/bld3). Ubisoft showed up in a big way with *The Division II* and *Ghost Recon,* and a few smaller indies fleshed out the presentation.

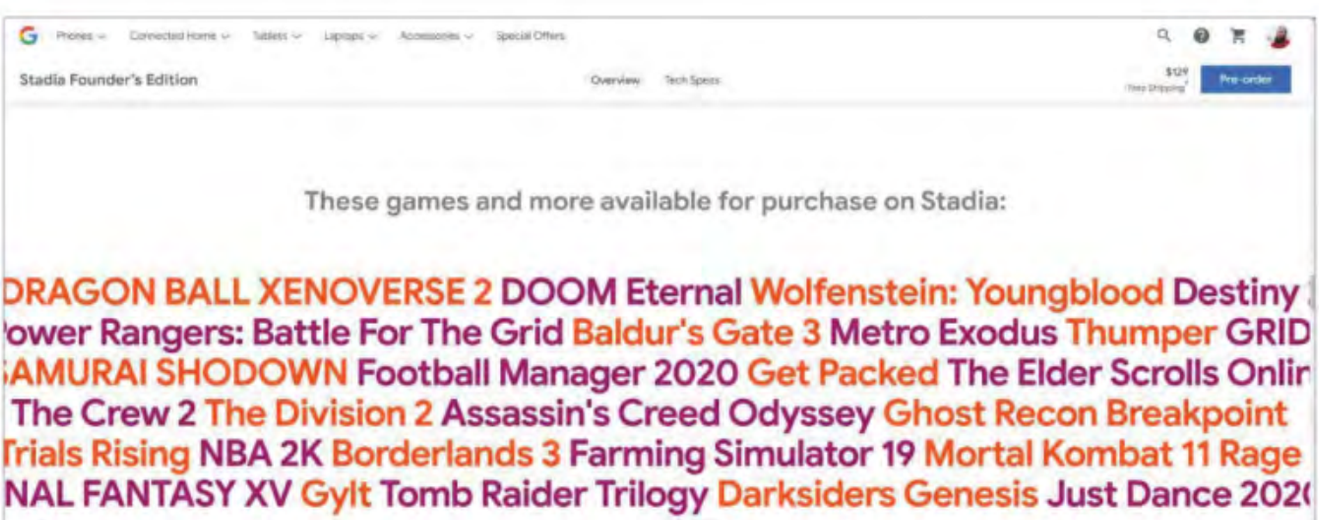
I couldn't help but notice Google prominently featured a Rockstar logo in its

IMAGE: GOOGLE

publisher rundown as well. Sure, it might only mean *Grand Theft Auto V* on Stadia—but could indicate a *Red Dead Redemption II* PC port. Maybe.

In any case, Stadia Pro is what Google focused on in its presentation, and for good reason. It's key to a bunch of features Google talked about in March, like clicking a button under a YouTube trailer or a walkthrough video and launching right into a game. That whole idea is less fun and exciting if you need to stop and enter your payment info.

"Stadia Base" seems to be exactly that though. Alongside the Stadia Pro subscription, players will be able to buy individual games as well. I'll be honest, that seems like a dicey prospect on an upstart platform where you, uh, don't actually own (or even download) anything—especially given Google's reputation for ditching



Some of the games set to support Google Stadia, via the Founder's Edition preorder page.

The *Ghost Recon Breakpoint* trailer showed a "Stream connect" Stadia feature that gives you a glimpse of your teammates' screens in real time.

projects that aren't working out.

For now, it's hard to know whether Stadia Pro will be a good value or whether that awkwardly named Stadia Base (a.k.a. The Way Every Store Works) will dominate. Hell, even though this was Google's big blowout event, it still feels like a lot of crucial details are missing, including a hard release date.

Instead it sounds like we'll get a rolling series of launches, similar to past Google platforms. If you want to be one of the first into Stadia, you can buy the Stadia Founder's Edition for $129 (go.pcworld.com/stfe). It comes with a controller, a Chromecast Ultra, three months of Stadia Pro (plus a buddy pass), and *Destiny 2*. Tests will begin in November, meaning the rest of us won't see Stadia until sometime in 2020, presumably. On the Sunday after Google's Stadia event, Microsoft countered with its own Project xCloud details at its own E3 press conference. The Project xCloud streaming service is due to arrive in October.

For now, I can't say anyone's really sold me on streaming or subscriptions, but it looks like the industry is headed in that direction in a hurry. The next generation's certainly going to be an interesting one.

10 new features Apple borrowed, copied, and stole from Google, Samsung, Microsoft, and Fitbit

Apple unveiled a list of new things during its WWDC keynote, but most of them were old news to Android fans. **BY MICHAEL SIMON**

Apple's WWDC keynote was jam-packed with an array of new features, apps, and tweaks designed to make our Apple device prettier and more powerful than ever before. Come September, Apple devices new and old will have an assortment of new tricks to try in iOS 13, iPadOS, and watchOS 6, and to hear Craig Federighi and company deliver the news, they'll be nothing less than ground-breaking, earth-shattering, and straight-up revolutionary.

IMAGE: APPLE

Dark Mode may be pretty but it's not new.

But while the new updates may indeed be as dramatic and delightful for iPhones, iPads, and Apple Watches as Apple says they are, they're not exactly new. At least not for anyone other than Apple users anyway. Most of the marquee features Apple announced have already been done before, and as the crowd whooped and hollered at every obvious applause break, Android and Fitbit fans were likely smirking rather than clapping.

1. DARK MODE

Yes, Apple delivered dark mode for the menu bar and Dock with Yosemite and expanded it to apps with macOS Mojave last year, but Dark Mode on smartphones is old hat. Google's has had a dark theme on its phones for years, and Samsung introduced a systemwide dark mode with its One UI redesign (go.pcworld.com/1uir) earlier this year. When Apple says Dark Mode is "thoughtfully designed to make every element on the screen easier on your eyes and is seamlessly integrated throughout the system" just remember that Galaxy and Pixel users had it first.

2. DOWNLOAD MANAGER

This feature is so overdue Apple doesn't even have a fancy name for it. In iPadOS, you'll be able to "see your active and recent downloads in Safari and access them easily from the new Downloads folder in Files," thanks to the existence of a bona fide downloads manager. Talk to any Android user and they won't be able to remember a time when they couldn't do that.

A wrist-sized app store is nothing new for Wear OS users.

incredibly exciting for iPad fans, the new OS finally breaks the iPad free from the constraints of the phone-first iOS and gives the tablet a bright future as a true Mac replacement.

But while there's a lot that's new, the most striking visual change—widgets on the home screen—arrived on Android with Honeycomb way back in 2011. We won't discuss how sorry the current crop of Android tablets are, but hey, at least Google got one thing right.

3. WATCHOS APP STORE

The ability to search, download, and install apps on your wrist is a huge step for the Apple Watch, but it was a bigger deal when Google launched the Play Store for Android Wear (go.pcworld.com/awr2) watches back in 2017. And Google even let developers build watch-only apps back then too. Granted, the state of Wear OS and compatible devices leaves much to be desired, but Google can at least claim it reached watch independence way before Apple did.

4. iPAD HOME SCREEN WIDGETS

One of the biggest WWDC announcements (aside from that $999 display stand that doesn't actually include a display) is the emergence of iPadOS. Long overdue and

5. DESKTOP BROWSING ON iPAD

At long last, the Safari browser on the iPad will no longer default to the mobile version of websites. Apple has finally realized that iPad users deserve the same internet experience that you get on the Mac, so it's opening up the full desktop version of Safari in iPadOS. However, anyone who's used a Chrome tablet will just snicker since they've had a full browser all along.

6. LOOK AROUND

Alongside a ground-up rebuilding of its mapping data in the U.S., with richer detail and (hopefully) more accurate directions, Apple introduced a feature called Look Around, which lets you "explore cities with an immersive 3D experience that lets you pan around 360 degrees and move seamlessly

Street View, anyone?

down streets." If that sounds familiar, it's because it is. Google called it Street View and it's been around as long as the iPhone. And Apple's other big Maps feature? Favorites. Because, you know, we haven't had that in Google Maps since forever.

The HomePod now recognizes who is talking and responds accordingly.

7. HOMEPOD VOICE RECOGNITION

The HomePod is an easy target for Google Home users, but Apple hasn't given up on making its smart speaker a viable option for your house. In addition to a new voice for Siri that speaks with nuance, the HomePod can recognize who is talking and cater its responses accordingly. That's great, but it was even better when Google brought it to Assistant last year.

8. QUICKPATH TYPING

Apple describes its new QuickPath Typing as if it's a feature you've never heard of before: "Simply swipe from one letter to the next without lifting your finger to enter a word. On-device machine learning recognizes the path you draw and converts it for you, making one-handed typing a breeze." Even if you forget about Swipe,

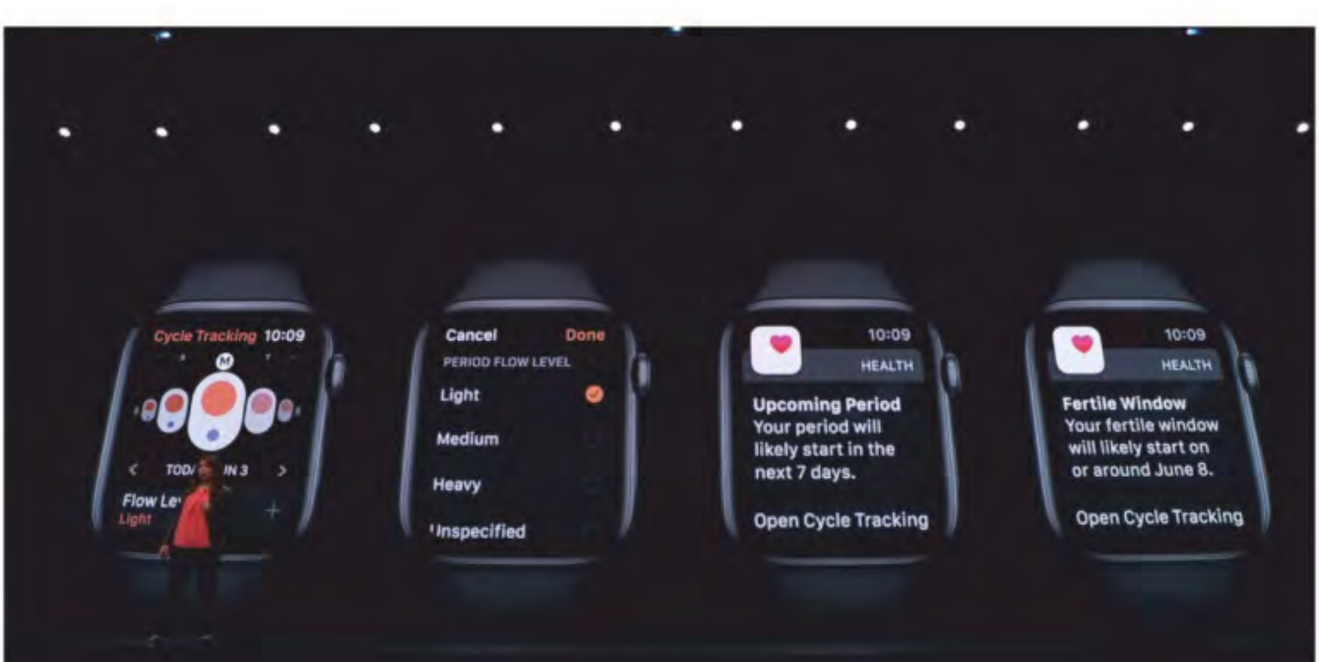
which pioneered slide typing when the iPhone was just a glimmer in Steve Jobs's eye, Google has been using swipes on its Gboard keyboard since 2016 when it launched exclusively on…wait for it…iOS.

9. FEMALE HEALTH TRACKING

The Apple Watch picked up a bunch of new health and fitness features with watchOS 6, but none are more important for women than the Cycle Tracking app, which lets users log period flow level and symptoms on their wrist. Fitbit launched female health tracking on your wrist, and period-tracking app Clue already offers an Apple Watch app. So while we commend Apple's efforts here, it's more of an "it's-about-time" feature rather than an innovative one.

10. VOICE CONTROL

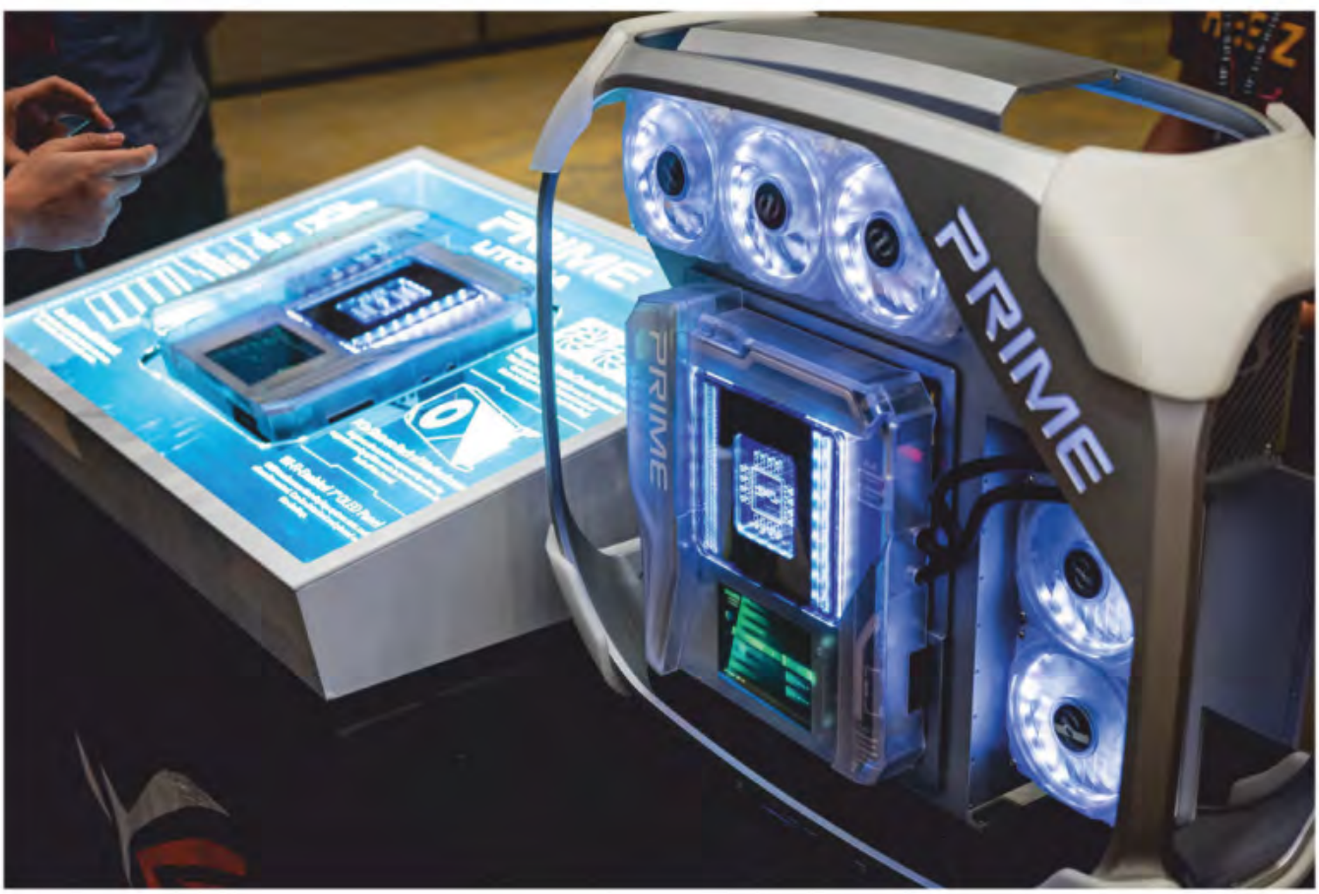
One of the more touching demonstrations during the WWDC keynote was watching a Mac user in a wheelchair effortlessly navigate his Mac, share photos, and send messages, all without a mouse. It's all part of Apple's new Voice Control feature that uses comprehensive commands to interact with apps and numbered labels to make selecting and clicking items on the screen easier. But while it's sure to be a life-changing feature for impaired Mac users, they could have been using it all along if they had bought a Windows 10 PC. Windows Speech Recognition (which has actually been around since Windows 7) is a robust and comprehensive way to control every inch of your PC without a mouse or a keyboard, and uses a similar numbering and grid method. So score one for Windows.



Female health tracking for Apple Watch is a great feature, but it's overdue.

The monstrous, momentous PC hardware of Computex 2019

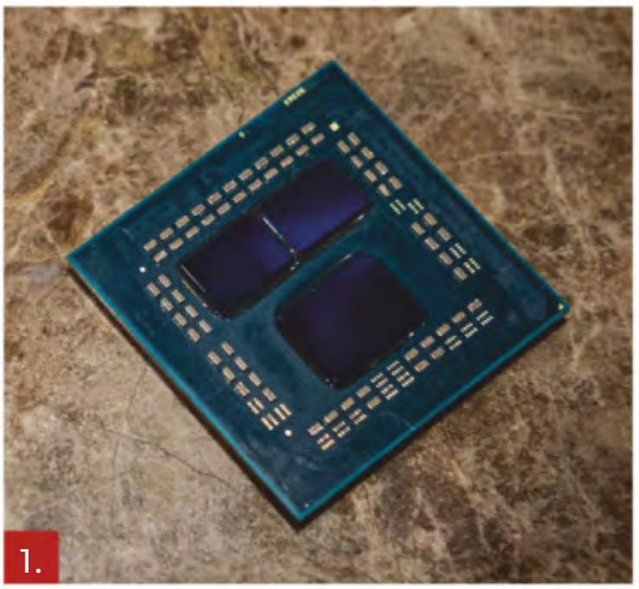
From futuristic laptops to trailblazing new chips, this is the PC hardware that caught our eye at Computex 2019. **BY BRAD CHACOS**



CES is where the technology industry goes to dream. Computex, in Taipei, Taiwan, is where things get real ahead of the crucial back-to-school and holiday seasons. At this year's show, some of the PC's most ambitious dreams are finally becoming tangible.

This was a Computex to remember. AMD flexed its hard-earned 7nm muscle, beating both Intel and Nvidia to the punch with cutting-edge Ryzen and Radeon chips. But those giants pushed back hard, rolling out new laptop initiatives—and Intel's long-delayed 10nm processors.

Chipmakers weren't the only companies strutting their stuff. Computer makers showed off all sorts of wild new gear, from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wood-clad laptops to funky multi-screen notebooks to a radical new vision for desktops that move beyond the boring-old ATX form factor. And did we mention PCIe 4.0 is a thing now?

Buckle up, and be sure to hit those links throughout to learn more about each topic.

1. AMD'S CUTTING-EDGE RYZEN ONSLAUGHT

AMD kicked off Computex with a bang (go.pcworld.com/bang), revealing its hotly anticipated Ryzen 3000-series processors—culminating in a monstrous 12-core, $500 chip that marks the debut of the Ryzen 9 family. Eight-core Ryzen 7 processors were also announced, with stupid-good power efficiency, higher clock speeds, and a launch date of July 7. These will be the first 7nm chips ever to hit the streets.

They'll also be the first processors to support the cutting-edge PCIe 4.0 interface, although you'll need a new X570 motherboard to take advantage. Fortunately, you should have plenty of options, as Asus alone plans on launching over 30 different X570 boards.

2. RADEON RX 5700

You know what else supports PCIe 4.0? The Radeon RX 5700 (go.pcworld.com/bang), the first consumer 7nm GPU, and one based on AMD's fresh "Navi" architecture, now dubbed RDNA. AMD says the Radeon RX 5700 should go toe-to-toe with the GeForce RTX 2070 and offer 25 percent better performance per clock and 50 percent better performance per watt than existing Radeon Vega GPUs. Navi GPUs will also advance to the speedier GDDR6 memory that debuted alongside Nvidia's RTX 20-series. Yes, please!

For even more juicy AMD info that wasn't announced onstage—like Threadripper's status, Radeon ray tracing, and whether benchmarks matter—check out our interview transcript with CEO Lisa Su (go.pcworld.com/lisa).

3. SUPERCHARGED PCIE 4.0 SSDS

Sure, the Radeon RX 5700 tease is exciting and all, but when it comes to PCIe 4.0 support specifically, moving to the cutting-edge interface should provide a much bigger boost to systems loaded down with NVMe storage. At Computex, Corsair unveiled the MP600 Force Series SSD (go.pcworld.com/mp60), a drive that taps into PCIe 4.0's capabilities to unlock ludicrous speed. This beast hits 4,950MBps sequential read speeds and 4,250MBps sequential write speeds. Oh my. Even better? As impressive as that is—and it is—Corsair's SSD doesn't come close to saturating PCIe 4.0's theoretical 8GBps maximum.

Corsair wasn't the only manufacturer climbing this horse. Gigabyte also showed an Aorus-branded PCIe 4.0 SSD (go.pcworld.com/aros) with a whopping 8TB of capacity. Don't expect that to come cheap.

If you build a new rig this fall and load up with Ryzen 3000, the Radeon RX 5700, an X570 motherboard, and one of these monsters, you could live the next-gen life with a full PCIe 4.0-compatible system. Giggity.

But the industry's eyes ever point forward: Also announced at Computex, the PCI Express 5.0 spec will bring 128 gigabytes per second of throughput (go.pcworld.com/ex50) to your PC…someday. Don't expect it anytime soon.

4. INTEL DIVES INTO 10NM ICE LAKE

AMD's triumphant keynote couldn't take away from Intel's blockbuster news: After years of delays, frustrations, and endless 14nm process tweaks, Intel's 10nm processors are finally here in the form of 10th-gen "Ice Lake" Core processors (go.pcworld.com/10gn) for laptops. Somewhat surprisingly, Intel played coy about detailed speeds and feeds of individual chips, but several PC makers already showed systems with Ice Lake inside.

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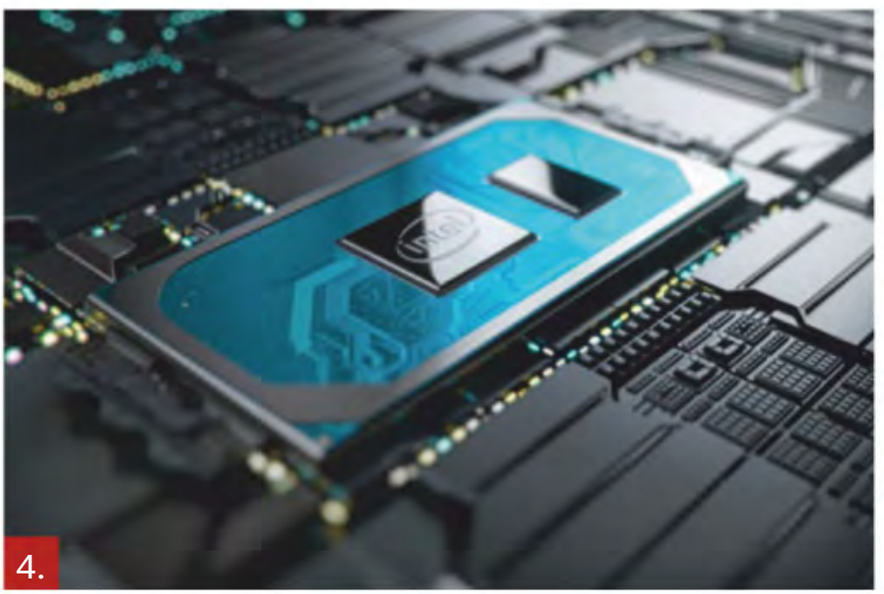
10th-gen Core chips don't quite hit the



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same maximum turbo speeds as their predecessors—again, Intel's been fine-tuning 14nm for years and years now—but they feature Dynamic Tuning 2.0 with Machine Learning that help manage turbo boosts more intelligently, with the aim of holding clocks as high as possible for as long as possible.

The 10th-gen Core chips also bake in other AI enhancements, along with platform upgrades like Wi-Fi 6 Gig+, Thunderbolt 3, and improved onboard graphics. In fact, Intel says that Ice Lake's integrated graphics top the Radeon cores (go.pcworld.com/ilak) in AMD's mobile Ryzen chips. Bold claim, that.

Intel also revealed what's inside Project Athena laptops (go.pcworld.com/atna), its vision for the ultra-light, long-lasting, always-connected notebooks of tomorrow. The first batch should consist of around 30 premium laptops.

5. INTEL DESKTOP LOVE

Ice Lake stole the show, but Intel didn't neglect desktops completely. In fact, it announced its fastest consumer processor ever at Computex. The company already called its Core i9-9900K the "best gaming CPU," and our tests confirmed it (go.pcworld.com/rvi9). The newly announced Core i9-9900KS (go.pcworld.com/cri9) outmuscles it by pushing all

5.

eight cores to 5GHz while boosting. Yowza. Often, boost clock ratings apply only to a single core. The Core i9-9900KS also maintains a higher 4GHz base clock. Further details weren't released.


6.

You might be able to push it even further with Intel's blessing. The company announced a new Performance Maximizer one-click overclocking tool (go.pcworld.com/maxm), which puts your 9th-gen K-series chip through a series of automated tests to find its upper limits. To coincide with the Performance Maximizer's enthusiast focus, Intel also announced the return of the Performance Tuning Protection Plan, which will replace your Core processor if you blow it up during your overclocking adventures. It costs $20 for three years of protection.

On the storage front, Intel announced its 2nd-gen Optane Memory M15 drive (go.pcworld.com/m15d), an upgraded version of the company's caching technology that pairs with your primary storage to supercharge the speeds of your most-used files and apps. The latest version gets an overdue update from two to four PCIe lanes, making Optane Memory even faster.

6. NVIDIA RTX STUDIO LAPTOPS AND ADAPTIVE SYNC REVELATIONS

Nvidia had a quieter Computex than its rivals, but still made some announcements of its own. Most notable: RTX Studio laptops (go.pcworld.com/rtxs), a new program that matches fully loaded, performance-oriented-yet-sleek laptops—with dedicated ray-tracing hardware, natch—and specialized Nvidia Studio drivers optimized around content creation apps. The antithesis of Intel's slim, long-lasting Project Athena laptops, RTX Studio laptops are built for people who need to get hard work done fast.

On the consumer front, Nvidia revealed why its G-Sync Compatible program flunks over 94 percent of FreeSync monitors (go.pcworld.com/94pc), and it's an interesting read. The company also said it's launching the

7.

ray-traced reimagining of *Quake II* (go.pcworld.com/riq2) on June 6—on both Windows and Linux—and entering a partnership with Bethesda to include RTX technologies and Adaptive shading in *Wolfenstein: Youngblood*. If you buy an RTX 20-series graphics card, Nvidia will toss in a free copy of the game.

7. HP LAPTOPS

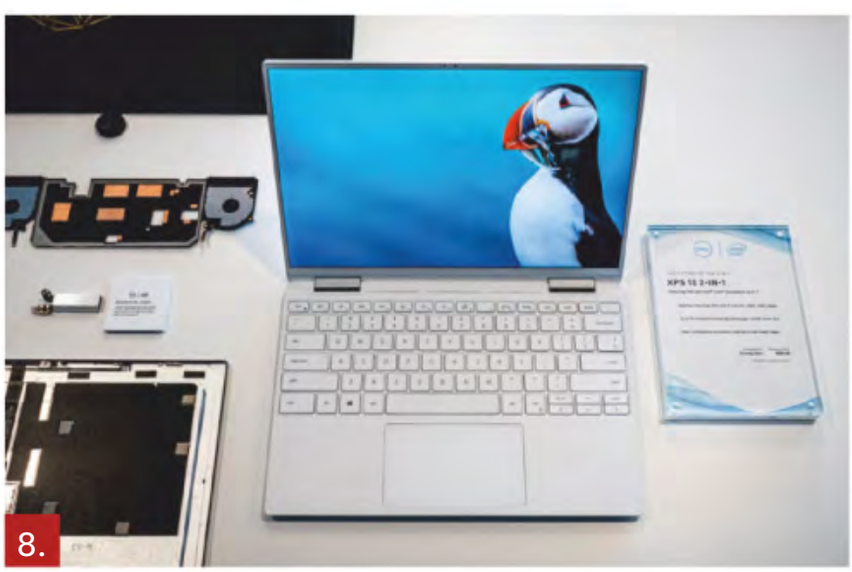
Now, let's shift focus to the computers where all this funky fresh hardware will reside. First up: HP. The company announced a full selection of its wonderful Envy laptops and 2-in-1s clad in wood (go.pcworld.com/wood). The natural elements cover only the keyboard's wrist area and touchpad, but HP paired its wood options with metals colored to match, and they look dreamy.

For the business crowd, HP also announced new Elite-series laptops (go.pcworld.com/elte), with options ranging from a claimed 24-hour battery life to a panel blazing at a fierce 1,000 nits of brightness. For context, that's just as vibrant as Nvidia's glorious G-Sync Ultimate displays (go.pcworld.com/ac27). Yes, please.

8. DELL LAPTOPS

Dell showed up with some heavy firepower, too—literally, in the case of the upgraded Alienware m15 (go.pcworld.com/alin). The new Dell Inspiron laptops (go.pcworld.com/in13) bring premium amenities with a budget-friendly price, too. But it's the redesigned XPS 13 2-in-1 that caught our eye the most.

Long the forgotten member of the XPS



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laptop lineup, Dell's new XPS 13 2-in-1 steps into the spotlight (go.pcworld.com/splt) thanks to a substantial overhaul intended to bring all the benefits of Intel's 10th-gen Core chips, while keeping the device slim and sleek. Dell rebuilt the entire cooling system to fit in a powerful "Ice Lake" Core i7 CPU and potent Iris graphics, along with much faster memory and a fabulous 4K panel that helps reduce eyestrain at night.

9. GIGABYTE'S TINY AERO GETS BIGGER

Look, we've adored (go.pcworld.com/ae15) every version of the Gigabyte Aero 15 that we've touched. And we can't wait to touch the new Gigabyte Aero notebooks unveiled at Computex. Gigabyte stuffed its surprisingly portable gaming laptop with Intel and Nvidia's latest hardware, and introduced a bigger sibling to the lineup, the Aero 17. Watch Gordon tour Gigabyte's laptops here (go.pcworld.com/t5our).

10. MSI

MSI brought heavy firepower to Computex. We took a peek at its biggest guns during our booth tour, from a beastly laptop designed to take on the Alienware 51m to a wild curved PC case that shows off all your

gear. Watch our MSI booth tour at go.pcworld.com/msib!

11. ASUS ZENBOOK PRO DUO

Laptops with dual displays are suddenly all the rage, but the dazzling Asus ZenBook Pro Duo (go.pcworld.com/prod) tells other contenders to hold its beer. This engineering marvel somehow manages to jam a 15.6-inch screen and a 14-inch screen into a 5.5-lb laptop, and both—yes, both—hit 3,840 pixels of horizontal resolution for 4K-quality visuals. (The auxiliary screen is built above the keyboard, so its vertical pixel count can't quite hit the 4K standard.)

Don't be fooled by the delicious eye candy, though. This laptop's built for power users, so Asus outfitted it with top-tier hardware, including up to an 8-core Core i9-9980HK, 32GB of RAM, a 1TB SSD, and a GeForce RTX 2060, as well as Intel's newest WiFi-6/802.11ax controller. Hot damn.


11.

12. THE FUTURE OF THE PC?

The Zenbook Pro Duo wasn't the only glimpse of a potentially radical future for the PC at Computex, though. Intel showed off

12.

not one, not two, but three wild concept PCs at the event (go.pcworld.com/wild), ranging from an "Ambient PC" with an always-on edge display and far-field microphones listening for your every word to a dual-screen monster of a gaming laptop that has a second hinge to lift its keyboard-topping screen—and the primary one above it—even higher. Super cool stuff, although we won't see the fruits of this labor anytime soon like we will with Project Athena notebooks (go.pcworld.com/athl).

Asus didn't stop innovating with its badass laptop, though. The company also showed off its radical Prime Utopia desktop prototype (go.pcworld.com/utop), which frankly looks like a PC plucked from an alternate timeline. It imagines what could be if we ditched the 25-year-old ATX standard to create something vastly more interesting. Be sure to hit that link and check it out.

13. QUALCOMM TEMPTS LAPTOP MAKERS

Finally, Qualcomm's still trying to convince laptop makers to opt for its long-lasting chips and achieve all-day battery life with go-anywhere connectivity. At Computex, the company revealed benchmarks that show its Snapdragon 8cx processor (go.pcworld.com/s8cx) matching the speeds of a circa-2017 Intel Core i5 chip. Qualcomm also partnered with Lenovo to showcase "Project Limitless," based on the 8cx, to create what it calls the first 5G-capable laptop. By Computex 2020, we'll know whether other notebook vendors are picking up what Qualcomm's putting down in the PC space.

13.


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MSI GS65 Stealth Thin: This thin gaming laptop features 9th-gen Core and GTX 1660 Ti

Can MSI's beloved GS65 Stealth Thin 9SD still stand out in a crowd of "me-too" thin gaming laptops? **BY GORDON MAH UNG**

The MSI GS65 Stealth Thin 9SD has a tradition to uphold. Its predecessor, MSI's GS65 Stealth Thin 8RE (go.pcworld.com/m8re), was the laptop that changed our perception of just how much real gaming performance you could pack into a thin-and-light gaming laptop. With the next generation, we find essentially the same winning laptop design, stuffed with the latest toys from Intel and Nvidia.

We're not exaggerating about the original

IMAGE: ADAM PATRICK MURRAY

GS65 Stealth Thin 8RE's wow factor, either. It was just a hair over 4 pounds, in the same weight class as a MacBook Pro 15 or ThinkPad X1 Extreme, yet it packed way more firepower.

The newest incarnation of the MSI GS65 Stealth Thin 9SD ups the ante with Intel's newest 6-core 9th gen Core i7-9750H, along with Nvidia's gift to those who just don't give a damn about ray tracing (go.pcworld.com/brtx): A GeForce GTX 1660 Ti. Thanks to a slight lack of coordination between Intel's and Nvidia's product cycles. The GS65 Stealth Thin will find itself battling with laptops such as Acer's Predator Triton 500 (go.pcworld.com/t500) or Alienware's m15 Thin (go.pcworld.com/m15l), both of which feature older 8th-gen CPUs, but Nvidia's newer ray-trace-enabled RTX GPUs.

MSI's updated GS65 Stealth Thin features a 9th-gen Core i7-9750H and Nvidia's GeForce GTX 1660 Ti GPU.

SPECS

As we said, the GS65 Stealth Thin is the first laptop we've reviewed with Intel's 9th-gen mobile 6-core CPU (go.pcworld.com/6cre). Let's run down all the specs:

CPU: Intel 6-core 9th gen Core i7-9750H

Memory: 16GB DDR4/2667 in dual-channel mode

GPU: Nvidia GeForce GTX 1660 Ti

Display: 15.6-inch 144Hz "IPS-like" screen without G-Sync

Storage: 512GB WD SN520 NVMe M.2 SSD

Networking: 802.11ac using an Intel AC9560 controller and Rivet Networks E2500 gigabit ethernet.

Dimensions: 14 x 9.75 x 0.75 inches

Weight: 4.4 pounds

That last bullet point is worth pointing out. While the original GS65 we reviewed last year was stupidly light at 4 pounds, MSI has added about 6 ounces to it. Some of that heft likely came from welcome structural reinforcements compared to the original run, which we called "flexible." How flexible? Well, let's just say it was a little scary to pick it up by one corner. The current version doesn't

flex much at all, but it's definitely a little heavier unfortunately.

THIN PORTS

As a gaming and workhorse laptop, the GS65 brings on the ports. The right side gives you USB-A, Thunderbolt 3, miniDisplayPort and full-size HDMI. Careful observers will also note the dedicated power plug on the right side. That may tick off some right-handed gamers who don't like power cords on the same side as their mousing hand, but MSI does at least provide a right-angle plug to make routing less obtrusive.

On the left side you get two USB-A ports, an analog headphone port, mic-input, Kensington Lock Port, and gigabit ethernet using a Rivet Networks Killer NIC part (made by Atheros). For those seeking state-of-the-art 2.5Gb ethernet, the GS65 Stealth Thin isn't there yet. To be fair, however, very few homes or offices have routers that could take advantage of it.

The GS65 Stealth Thin 9SD controversially puts the power plug on the right side, which could annoy some gamers.

MSI's updated GS65 Stealth Thin features a 9th gen Core i7-9750H and Nvidia's new GeForce GTX 1660 Ti GPU.

KEYBOARD AND TRACKPAD

For keyboards, you get a SteelSeries dome-type with per-key RGB lighting. The key action is good and features full-sized cursor keys. Overall, there's no major faux pas, such as oddly placed or half-sized keys.

The keyboard features per key RGB lighting and a wide-aspect ratio trackpad with Microsoft precision driver support.

The trackpad, however, is going to cause consternation among some people. It's a wide aspect-ratio trackpad with a fairly smooth surface. The original GS65 Stealth Thin 8RE featured a more conventionally sized trackpad, centered on the Y key. The GS65 Stealth Thin 9SD's trackpad is so wide it's centered nearly an inch to the right of last year's model, making it almost impossible to keep your right palm off of it while typing. To its credit, however, the palm rejection is excellent. And if you mouse with your thumb instead of your index finger, as some people do, this trackpad is for you.

Our last word on the trackpad is to point out that it's compliant with Microsoft Precision Touchpad drivers. That means you get access to the full gestures of Windows 10, and technically it's been tested to meet the Microsoft's criteria.

UPGRADE OPTIONS: NOT FUN

Outside of hulks such as Alienware's Area 51m (go.pcworld.com/15r1), upgrades on gaming laptops are generally limited to storage and RAM. With the GS65 Stealth Thin, however, the inverted motherboard design places the two M.2 slots and two SO-DIMM slots out of reach. You'd need to remove ribbon cables and pull the motherboard out of the

MSI's GS65 Stealth Thin continues to use an inverted motherboard design which makes adding storage or RAM a scary proposition for most consumers.

We're we too harsh? There's no additional cores in the 9th gen Core i7-9750H but the performance boost is respectable.

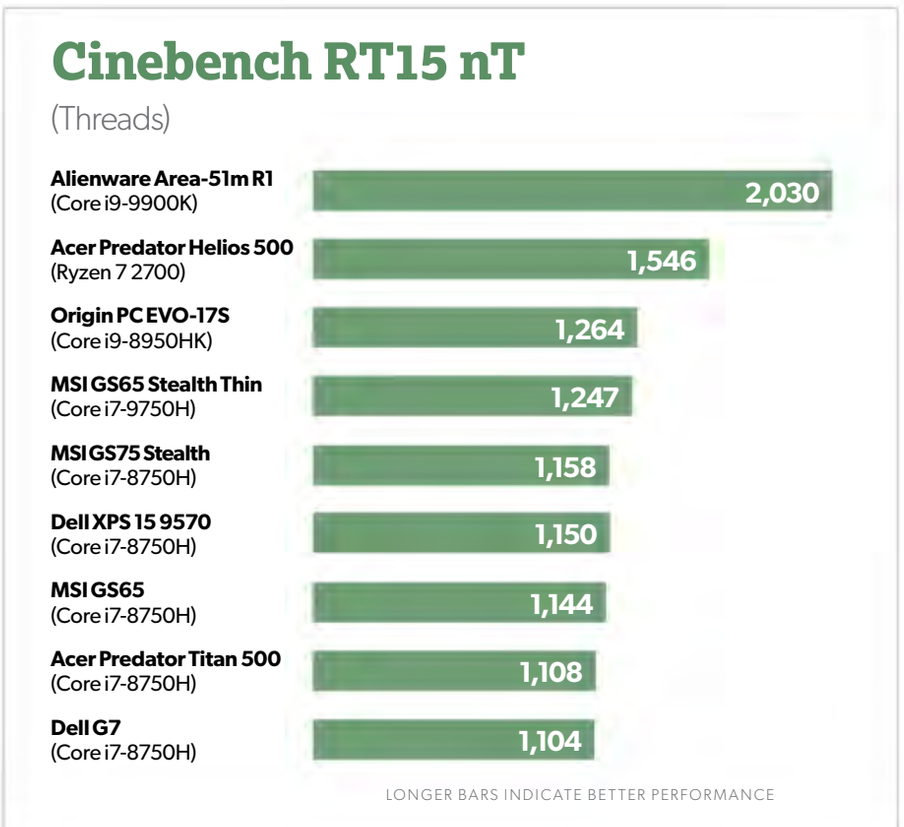
system to upgrade either. That's just not something the average person is going to attempt, because bending a ribbon cable would likely brick the laptop.

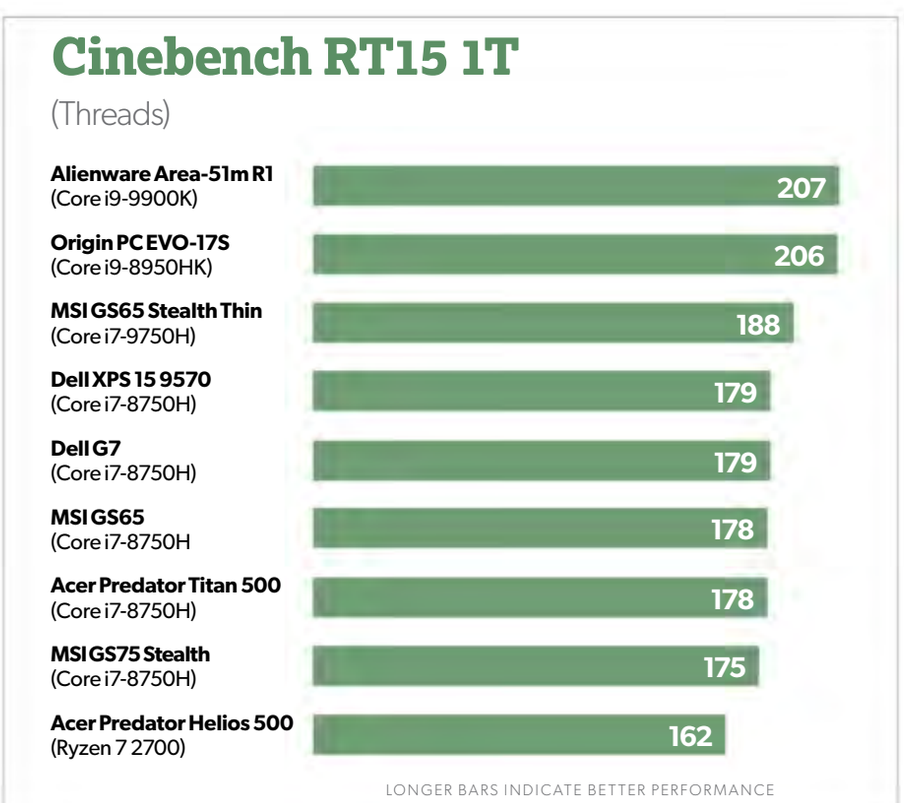
MSI isn't the only company to make life harder like this. Asus does it on its ROG Zephyrus, and Acer does it on its Predator Triton 500. We should note that bigger-sibling MSI GS75 (go.pcworld.com/75gs) at least gives you easy access to the M.2 drives.

PERFORMANCE

There are two big upgrades inside the GS65 Stealth Thin, and it's worth looking at just what you get. If you read our story about 8th gen Core i7 vs. 9th gen Core i7 (go.

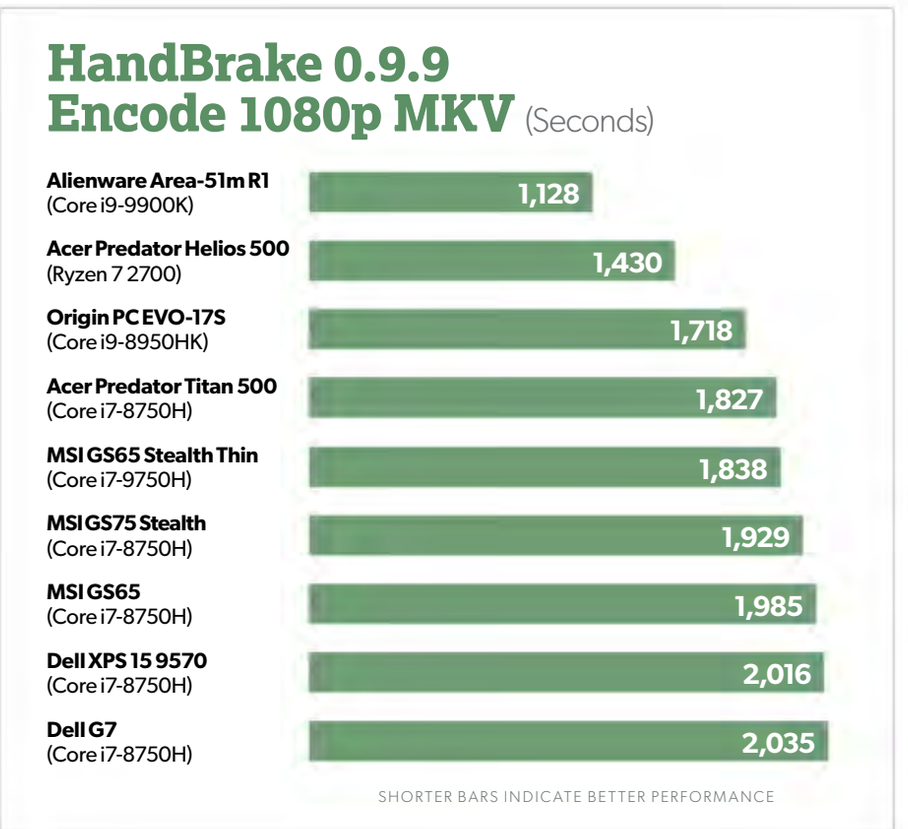
Single-threaded performance is marginally better than older 8th gen CPUs but enough to upgrade?





pcworld.com/9g8g), you that going from an 8th-gen Core i7-8750H to a 9th-gen Core i7-9750H is nothing major. There's no core jump from one generation to the other, for example. You still get a decent 15-percent base clock difference (where the CPU runs at during worst-case scenarios), and a 9-percent increase in Turbo Boost.

We see that play out in our Cinebench R15 3D modeling test, which pushes all the cores of the CPU. The GS65 Stealth Thin outpaces all Core i7-8750H laptops by a decent margin and can actually stand with 8th-gen Core i9 chips. For the most part though, we're looking at about 9 percent more performance.



In our lengthy HandBrake encode, we can see the impact of running the CPU harder for a longer period of time.

Running Cinebench R15 on a single core, we also see the 9th-gen pull out ahead. The difference narrows to about 5 percent between the old GS65 and the new one.

Cinebench runs in just a few seconds to couple of minutes. That's not enough to heat up the laptop. To see how it performs under more adverse CPU conditions, we use HandBrake to encode a 1080p video. The run can take 30 minutes on a 6-core CPU.

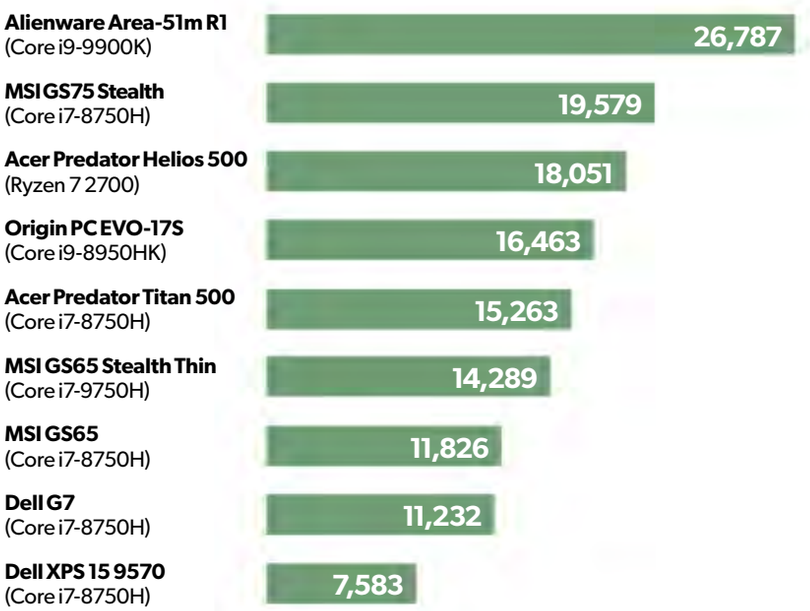
As you can see, the GS65 Stealth Thin does relatively well (about 7 percent faster) compared to other 8th-gen Core i7 laptops, but surprisingly it ties with the Acer Predator Triton 500. Acer is likely driving its CPU at higher clocks than usual compared to other 8th-gen laptops. It also confirms that overall, the 9th-gen CPU is a minor upgrade from 8th-gen.

GAMING PERFORMANCE

Our first gaming test is UL's popular 3DMark Fire Strike test. We focus on the graphics result, which filters out the CPU's impact. First up, we can see that when compared to the

3DMark Fire Strike 1.1 Graphics

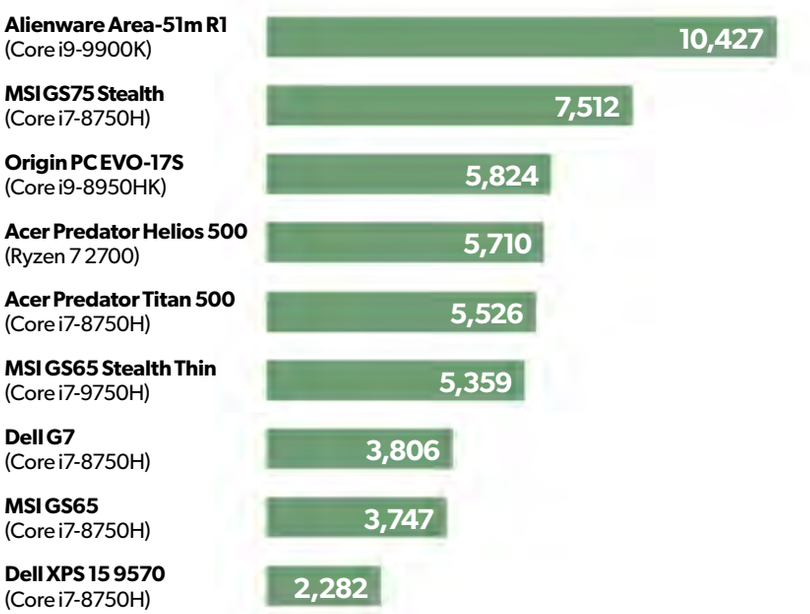
(GPU score)



LONGER BARS INDICATE BETTER PERFORMANCE

3DMark Time Spy 1.1 Graphics

(GPU score)



LONGER BARS INDICATE BETTER PERFORMANCE

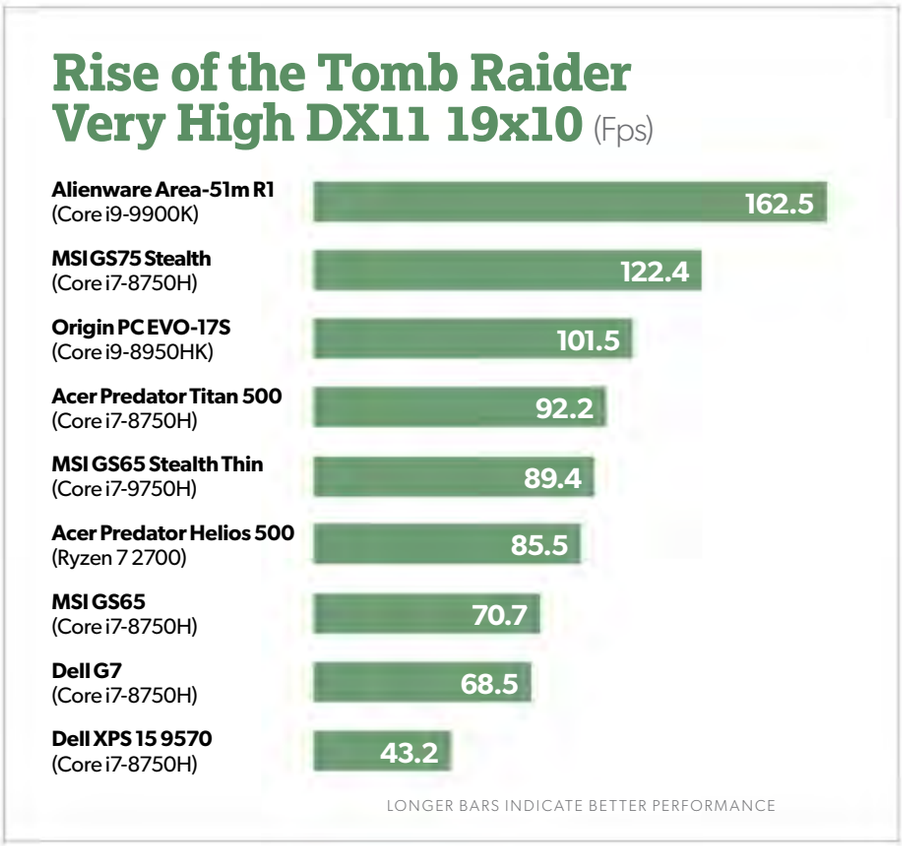
We saw about a 19-percent performance bump going from the previous GS65's GTX 1060 to the newer GS65's GTX 1660 Ti.

previous GS65 Stealth Thin 8RE and its GeForce GTX 1060, the 9SD sees a hefty 19-percent step up in performance.

One issue with Fire Strike is its vintage, so we also ran 3DMark Time Spy 1.1, which tests DX12 performance and uses far more advanced graphics techniques. For example, while Fire Strike might invoke 1.5 million shaders in one test, Time Spy will invoke 29 million. We see about a 35-percent jump in performance with the newer GS65 and its GTX 1660 Ti, over the original GS65 and its GTX 1060.

The GeForce GTX 1660 Ti easily outperforms

In DX12 tests with more shader and compute tasks, the GTX 1660 Ti easily steps away from GeForce GTX 1060 and GeForce GTX 1070 Max-Q laptops.



Rise of the Tomb Raider echoes our synthetic 3DMark results for the GS65 and its GeForce GTX 1660 Ti GPU.

GeForce GTX 1070 Max-Q laptops, which operate in similar size and thermal limits. The GTX 1660 Ti in the GS65 can even hold its own against laptops with full-fat GeForce GTX 1070 in larger and thicker laptops. That's a win in our book.

To back up our synthetic tests we also run real games, and the results pretty much track as expected. In *Rise of The Tomb Raider* at 1920x1080 resolution set to Very High quality and in DX11 mode, the GS65 Stealth Thin's GTX 1660 Ti runs away from the older GTX 1060, keeping pace with most GeForce GTX 1070 and GTX 1070 Max-Q laptops.

BATTERY PERFORMANCE

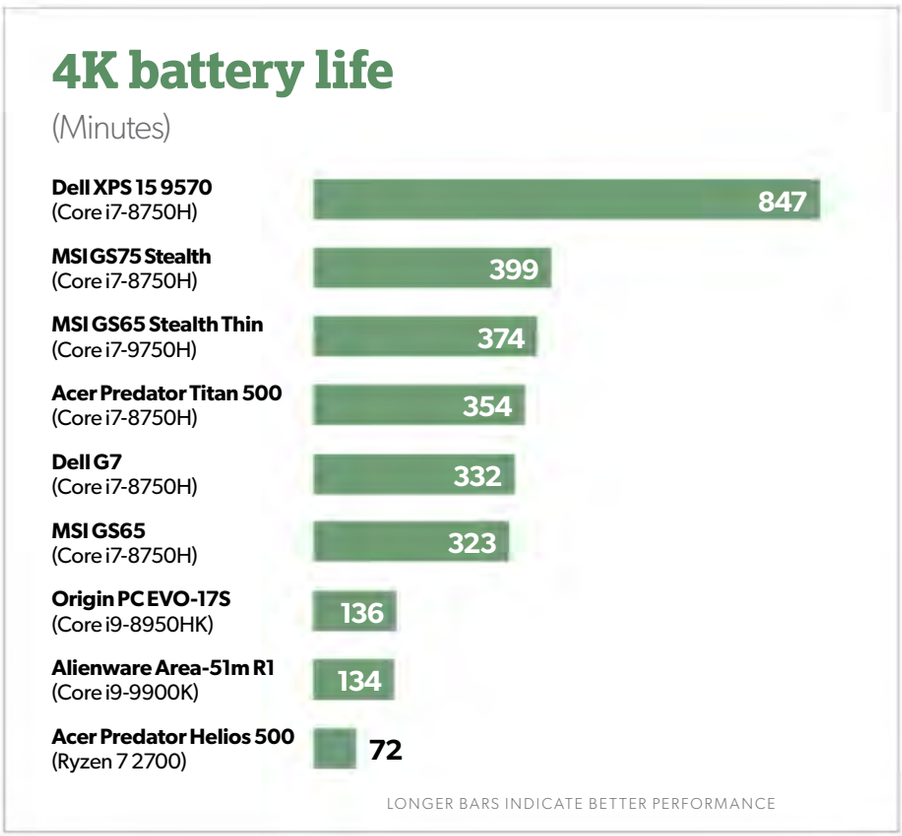
Our last test looks at the all-important battery performance. While large desktop replacements will likely they spend most of their life on a desk, portable gaming laptops mat get called into service because they're more mobile.

MSI's design cues for the newest GS65 follow what it did for the original GS65: It puts in a decently-sized battery of 80 watt-hours instead of saving on weight and size with a smaller one.

MSI also skips Nvidia's G-Sync technology, which means when the discrete GPU isn't in use, the laptop can run off the CPU's graphics cores and save power.

It all adds up to about six hours of battery life when playing a 4K video in

While large desktop replacements will likely they spend most of their life on a desk, portable gaming laptops mat get called into service because they're more mobile.



Rise of the Tomb Raider echoes our synthetic 3DMark results for the GS65 and its GeForce GTX 1660 Ti GPU.

airplane mode, at a relatively bright 250 to 260 nits. We'd rank that in the good range. In general use where you don't push the GPU or CPU hard, we'd say expect from four to six hours depending on the task. If you run a game or CPU-intensive task, expect battery life to plunge to an hour or two, in a worst-case scenario.

BOTTOM LINE

It's hard to believe but when we first saw the original MSI GS65 Stealth Thin 8RE a year ago, there was scant competition in its class. Sure, you had Gigabyte's Aero 15X series (go.pcworld.com/a15x) (heavier) and the original Asus ROG Zephyrus GX501 (go.pcworld.com/gx50) (faster but heavier, with compromised battery life), but few other players were pushing the kind of performance you got in the GS65 Stealth Thin.

Today, however, it feels like a whole different world. Besides Alienware's m15 (go.pcworld.com/lm15), Acer's Predator Triton 500 and the Razer Blade 15 (go.pcworld.com/bl15) among others, thin gaming laptops are a crowded field now. Against this crowded field, the GS65 Stealth Thin offers top-notch performance in its class and is very price-competitive too. It just doesn't have the same uniqueness it once did.

MSI GS65 Stealth Thin 9SD

★★★★☆

PROS

- Features the latest Intel and Nvidia hardware.
- Still pretty damn light.

CONS

- Trackpad is always under you palm.
- The extra six ounces of weight the newest GS65 puts it far closer to the competition.

$1,699

Lenovo ThinkPad X390: A sharp business laptop with caveats

It's fast and fully equipped, but some features disappointed us. **BY JARED NEWMAN**

The Lenovo ThinkPad X390 gets some things right. It's thin and light—especially for a business laptop—and plenty powerful, while maintaining the hefty keyboard for which ThinkPads are known.

Before long, though, the ThinkPad X390's trade-offs become clear. The matte display's washed-out tones are tiresome on the eyes, and the keyboard and touchpad—both signature features on most ThinkPads—feel too stiff. While the ThinkPad X390 performs well in benchmarks, fiddling with the power settings causes speed to suffer. Given the price, we expected fewer drawbacks.

IMAGE: JARED NEWMAN

SPECS AND FEATURES

The Lenovo ThinkPad X390 gives you plenty of ports.

The ThinkPad X390's price can vary greatly by configuration. It's possible to spend as little as $899 on this laptop, for which you'll get a good dollop of RAM (8GB) and a competent Intel Core i5-8265U processor; however, the low-resolution 1366x768 display and meager 128GB SSD are compromises.

Our review unit was closer to the opposite end of the spectrum, with an Intel Core i7-8565U processor and 16GB of DDR4 RAM; a 13.3-inch, 1920x1080p touchscreen, and a roomy 512GB SSD. It also includes a fingerprint reader and an IR camera for Windows Hello. All that brings the price up to $1,689.

Regardless of the model, you get plenty of ports, including two USB-A, two USB-C (one Thunderbolt 3), an ethernet extension, HDMI 1.4, and a Kensington Lock slot. There's even a removable tray around back for both MicroSD card and nano-SIM cards.

DESIGN AND DISPLAY

Unlike its ThinkPad L390 Yoga cousin (go.pcworld.com/l390), the ThinkPad X390 doesn't have a 360-degree hinge. Instead it folds 180 degrees, so the screen can lay flat on a table.

In exchange for less flexibility, the X390 is a much slicker machine, with bezels measuring just 0.38 inches. It weighs in at a respectable 2.9 pounds, a little heavier than Dell's XPS 13 (go.pcworld.com/9380; 2.7 pounds), about the same as HP's Spectre x360 (go.pcworld.com/hp19), and much lighter than the aforementioned L390 Yoga (3.36 pounds). That's all without sacrificing durability, as Lenovo puts the X390 through a battery of military-grade shock, sand, humidity, altitude, and temperature tests.

Whether you like the display will come down to personal preference. The X390 uses an IPS panel, which is supposed to provide great viewing angles. Tilting this unit's display changes brightness dramatically, however. No matter which angle you choose, colors look washed-out and overly cool, and the display starts to feel a bit harsh on the eyes in moderate lighting. Such are the inherent downsides of a matte display, compared to the glossy screens becoming more common on modern laptops.

As for the upsides, matte displays are better at cutting down glare. You can also dial down the X390's brightness to reduce eyestrain in environments such as a

The matte display is not for everyone.

fluorescent-lit office. Lenovo notes that matte displays are lighter, because they don't have a sheet of glass running across them.

To me, the benefits of glossy displays—vibrant colors, smoother touch input—outweigh the drawbacks. Either way, it's something to be aware of before spending upwards of $1,000 on this laptop, especially because Lenovo is planning to release a glossy-display version of the X390 later this year.

KEYBOARD AND TOUCHPAD

Typing is supposed to be best part of owning a ThinkPad. Even as other laptop makers slim down to unbearable levels of travel, Lenovo has been steadfast in supplying its business notebooks with luxuriously thick keyboards. Typing on the ThinkPad L390 Yoga spoiled me for most other laptop keyboards.

The X390's keyboard, however, is a surprising letdown. While it still offers lots of travel, it's also about a quarter-inch narrower than the L390 between the A and apostrophe keys. Something about that shrunken layout makes it feel stiffer. While my typing speed remained steady—I averaged 101 words per minute, versus 105 on my desktop keyboard—typing felt less comfortable. The keyboard also seemed to produce more mistakes in non-ideal environments (such as on my lap).

Perhaps in pursuit of thinness, Lenovo also compromised on the X390's touchpad. About halfway up, the click mechanism starts putting up a lot of resistance. Clicking down becomes almost impossible with about a quarter of the pad to spare. As with other ThinkPads, the X390 still provides dedicated left- and right-click buttons below the keyboard, and you can always just tap on the touchpad to select things, but this is not an ideal touchpad for folks who prefer to click down.

Even as other laptop makers slim down to unbearable levels of travel, Lenovo has been steadfast in supplying its business notebooks with luxuriously thick keyboards.

The X390 keyboard looks like that of every other ThinkPad, but it feels stiffer.

SECURITY, CAMERAS, AND SOUND

The Lenovo ThinkPad X390's webcam is your typical 720p model, but it does have a physical privacy shutter. Slide it into place, and a subtle red dot covers the lens to confirm that no snooping will occur. Lenovo plans to offer a "PrivacyGuard" display this summer to thwart inquisitive glances, but this wasn't available on our review unit.

For authentication, the ThinkPad X390 offers both a fingerprint reader and an IR sensor for Windows Hello face recognition. It's great having both options on one laptop, but keep in mind face recognition won't work when the privacy shutter is over the webcam.

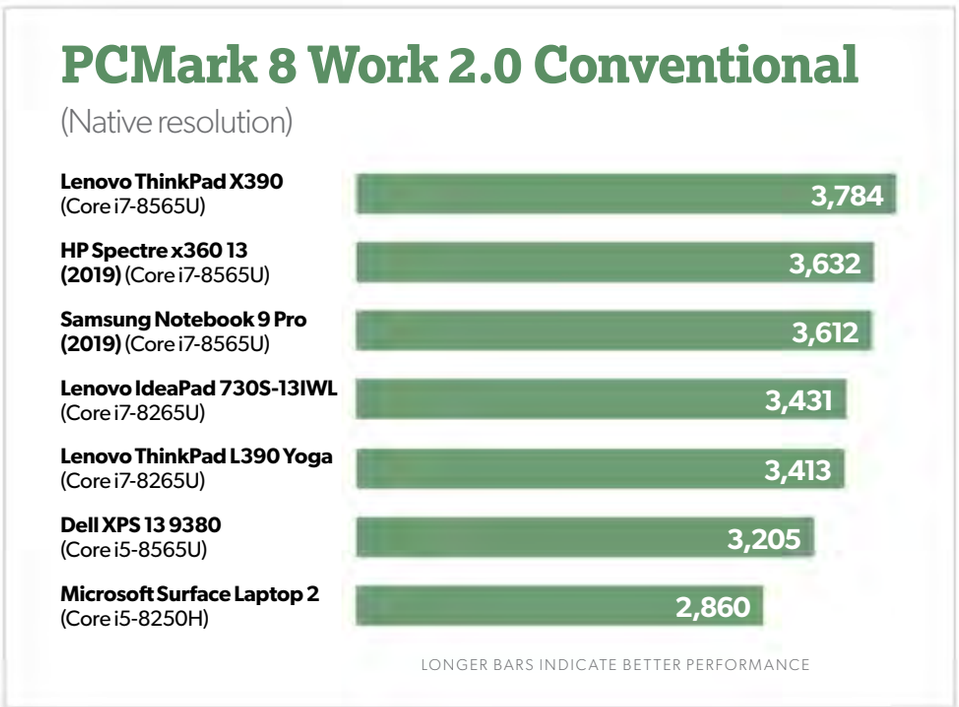
Sound quality is seldom a priority on business laptops—case in point for the ThinkPad X390, whose speakers are lacking in bass and not particularly loud. Lenovo says it uses a new audio signal processor for noise cancellation on its microphones, though, and here the results were excellent. A voice recording sounded crisp even with heavy-rain sounds playing on a nearby speaker. I tried this with a couple of other laptops (including the ThinkPad L390 Yoga), and the recordings were more muddled.

PERFORMANCE

It's no surprise that the fully loaded ThinkPad X390 we received made short work of its benchmarks. The laptop doesn't get too hot on its underside either, thanks to a vent that blows air out the right side. The system fan mostly stays quiet under basic productivity workloads.

One caveat, though: On Lenovo's default unplugged power setting ("Better Battery"), performance throttling becomes quite noticeable for certain tasks. While using the Windows app Tweeten (go.pcworld.com/twtn), for instance, scrolling seemed choppy, and web links took a while to load. Setting up the X390 side-by-side with Lenovo's ThinkPad L390 Yoga (with a lesser i5-8265U CPU and

According to PCMark, the ThinkPad X390 is good at business

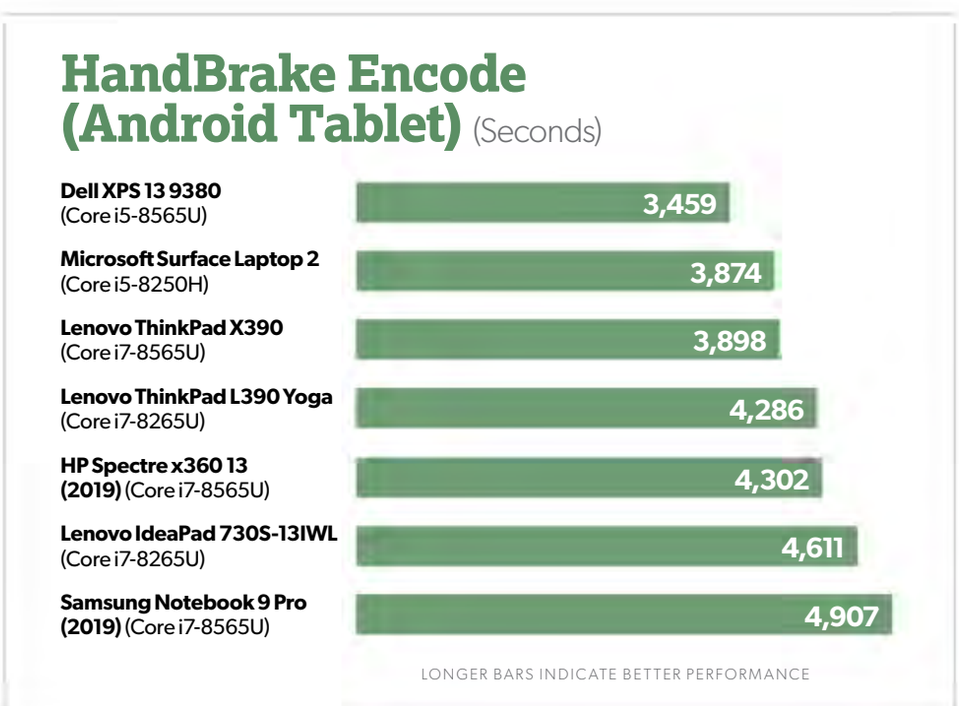


half the RAM), the latter routinely loaded webpages faster under the "Better Battery" setting. The X390 reestablished a clear lead only with both laptops on their "Best Performance" setting. Unless you're plugged into AC or willing to burn more battery life, you may miss some of the extra power you're paying for.

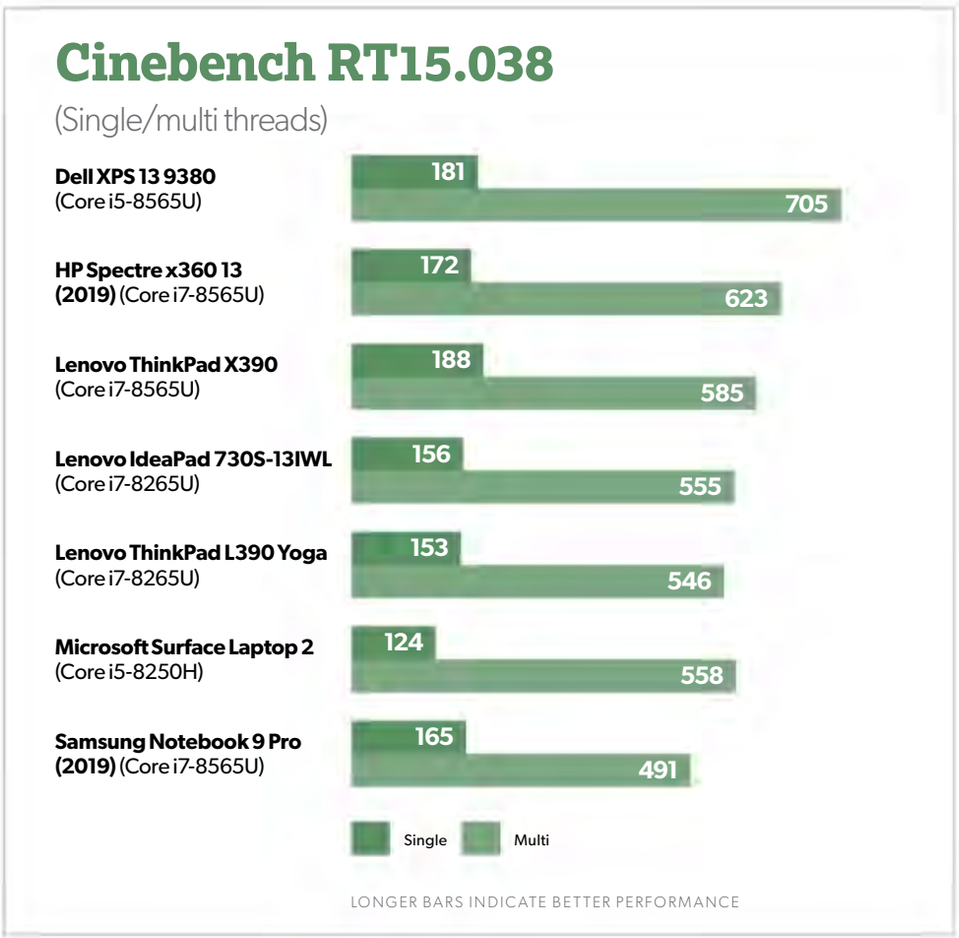
Now, onto the benchmarks.

PCMark 8's Work 2.0 benchmark cycles through simulated productivity tasks such as spreadsheet editing and video chat. It's obviously an important use case for business laptops, and any score over 2,000 is good. The ThinkPad X390's score of 3,784 topped that of every other thin-and-light laptop we've tested. Only HP's Spectre x360 and Samsung's Notebook 9 Pro came close.

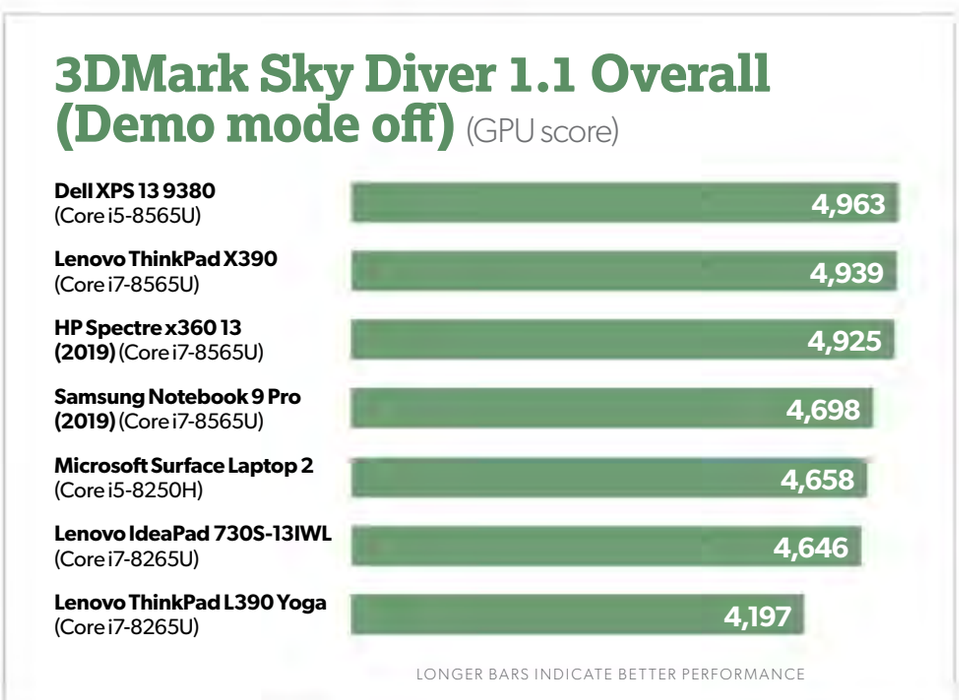
HandBrake was another highlight for the



For a 13-inch Core-i7 laptop, the ThinkPad X390 holds up well over a long period of intensive work.



While the multi-threaded results are nothing special, the ThinkPad X390 does well in Cinebench's single-threaded benchmark.



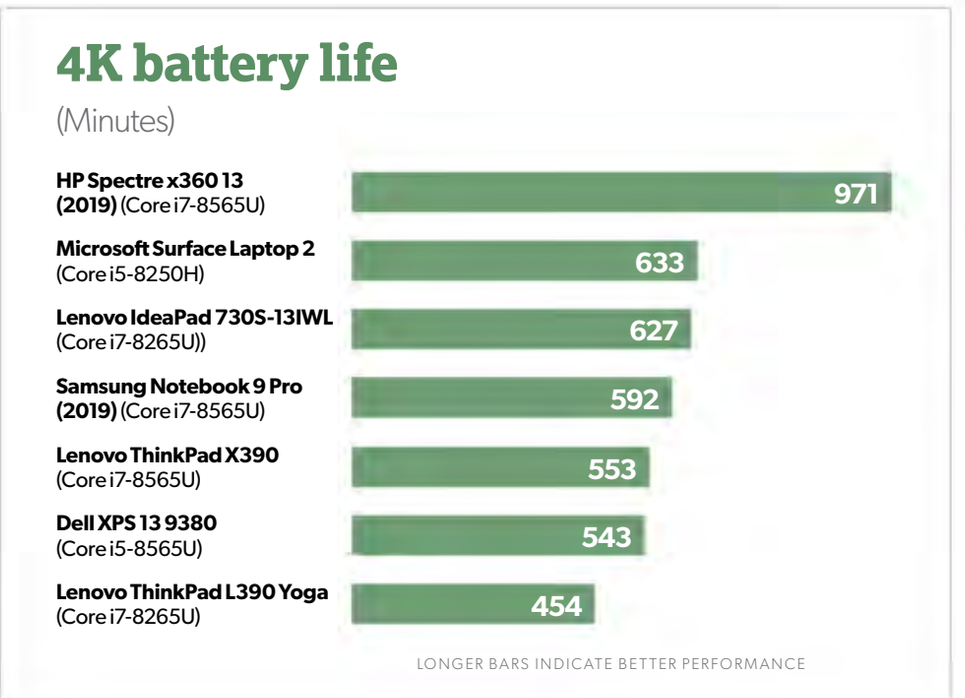
ThinkPad X390, which took about 65 minutes to encode our test .MKV video file to a smaller .MP4 file. Dell's XPS 13 fared better, but overall it shows that the laptop makes good use of its quad-core CPU over a prolonged period of heavy use.

As for Cinebench, which tests the CPU in short bursts, the X390 fell in the middle of the pack among Core i7-8565U laptops for multi-threaded performance. That said, it did well in the single-threaded test, which better reflects

You're not buying a ThinkPad for games, but the X390 does nicely against similar laptops in 3DMark's graphics test.

the applications most people use.

The X390 turned in solid scores on 3DMark Sky Diver 1.0, at least for a laptop with integrated graphics. In practice, this doesn't mean much, as you'll still want a dedicated GPU to play modern 3D games, but 2D indie-ish games should be doable.



When a small laptop packs in a hefty keyboard, plenty of ports, and a powerful CPU, something's got to give. In this case, it's battery life.

Battery life is the only significant sore spot. Many other factors can affect battery life, including screen brightness and resolution, and intensity of workload. The ThinkPad X390 has one obvious challenge: Its capacity of 49,410 mAh is smaller than that of competitors like the HP Spectre x360 (61,000 mAh) and Samsung Notebook 9 Pro (54,050 mAh). Batteries add weight and cost, so they represent one of many trade-offs in thinner, lighter laptops.

BOTTOM LINE

The Lenovo ThinkPad X390 is a frustrating laptop to review because it could—and perhaps should—be so much more than it is. It's an attractive package with impressive performance and lots of helpful business features. For the price, however, we expected better experiences with the display, keyboard, and touchpad.

Lenovo ThinkPad X390

★★★½☆

PROS

- Solid performance for its class.
- Impressively thin and light for a business laptop.
- Ports and security features galore.

CONS

- Matte display looks washed out and harsh in moderately-lit roms.
- Keyboard and trackpad are too stuff.
- Battery life lags behind similar laptops.

BOTTOM LINE

Lenovo's slimmed-down business laptop looks great from afar, but will strain your eyes and frustrate your fingers.

$899

OnePlus 7 Pro: Not a flagship killer, a flagship contender

More bang, more bucks, more everything. **BY MICHAEL SIMON**

PCWorld EDITORS' CHOICE

The OnePlus 7 Pro is everything a OnePlus phone isn't supposed to be. It has a better screen than the Galaxy S10+. It has a nicer design than the iPhone XR. And its front camera puts the Pixel 3 XL's notch to utter shame.

You might notice that those three phones all cost upwards of a thousand dollars, a stark contrast to the $669 7 Pro. But beyond the tremendous value, it's the first OnePlus phone I've used that truly feels like a flagship and not just a premium alternative. The previous OnePlus models all had attractive price tags while still packing top-of-the-line specs, but they never quite measured up to the phones they were challenging. The 6 and 6T were the phones to buy instead of a flagship. With the

IMAGE: CHRISTOPHER HEBERT

7 Pro, OnePlus has made a phone that Samsung and Apple should fear.

It's so good, in fact, that its deficiencies—namely the lack of wireless charging and IP-rated water resistance, and a camera that doesn't quite measure up to the Pixel 3 XL's—seem that much more glaring than they did on previous handsets. But even with those missing features and a few imperfections here and there, the OnePlus 7 is still a worthy entry to premium space. And we may never look at OnePlus the same way again.

STUNNING CURVES AND SMOOTH EDGES

OnePlus introduces a completely new design for the 7 Pro that's clearly inspired by the Galaxy S10+ and Huawei P30 Pro. Fans of those phones will note the obvious similarities with the "infinity" look, but the curved screen model here doesn't feel like a mere imitation.

We hear the term "all-screen" a lot, but the OnePlus 7 nearly lives up to it. The chin and forehead on the 7 Pro are barely-there slivers of black that give the 7 Pro a balanced and luxurious feel, though it bothers my eyes that they're not quite symmetrical. The aggressively rounded corners of the screen match the body of the phone perfectly. Compared to the 6T's flat-screen design, the 7 has a luxuriousness that rivals that of the Galaxy S10+ and iPhone XS. Once you run you fingers along its sloped edges, you won't want to put it down.

The cherry on top: There's no notch or hole to be found. OnePlus pulls off the 7 Pro's greatest trick with a pop-up selfie camera that magically rises from the top edge when summoned. The mechanism is smooth, fast, and whisper-quiet, and it gives the phone a real futuristic feel. You probably shouldn't overdo it, due to the natural tendency for moving parts to break, but you'll certainly be tempted to.

The rear camera isn't quite as inventive, but there are three of them this time around.

The OnePlus 7 Pro's curved Fluid AMOLED screen (left) looks even more gorgeous next to the flat-screen 6T.

OnePlus solves the notch with a pop-up camera.

As with the 6T, they're mounted vertically with a slight bump, and set against a back panel that's clad in a gorgeous matte-blue-, gray-, or almond-colored glass.

The button and port layout is also the same as the 6T's, which has its pros and cons: You get the awesome alert slider, but unfortunately that also means the headphone jack is missing. Theoretically, OnePlus could have used the 7 Pro's extra thickness (8.8mm, versus 8.2mm on the 6T) to bring back the audio jack. Alas, you'll need to use Bluetooth headphones or buy an adapter—OnePlus isn't supplying one in the box anymore.

AMAZING SCREEN, SO-SO FINGERPRINT SCANNER

One aspect of the OnePlus 7 Pro that might be a deal-breaker for some: It's big and heavy. With a whopping 6.67-inch display and a 162.6 × 75.9mm frame weighing 206 grams, it's easily a contender for biggest smartphone of the year, topping the iPhone XS Max and just a hair smaller than the 6.7-inch Galaxy S10 5G (which starts at $1,299, but who's counting).

Assuming you don't mind the size, you'll have a hard time finding a better display. OnePlus calls it Fluid AMOLED, and it's just as dazzling as Samsung's Dynamic AMOLED. It offers a crisp QHD+ (3120x1440) resolution at 516ppi, remarkable brightness, and a 90Hz refresh rate for impeccable animations and gestures. In lay terms, it's an absolute joy to use. The only thing I missed was an always-on

The in-display fingerprint scanner still isn't as good as a physical scanner.

option, but the tapping and raising-to-wake are plenty effective.

OnePlus has stuck with its in-display optical fingerprint sensor. While it's less finicky than we experienced on the 6T, it still feels like a step backwards. It's incredibly fast when it works, but on a whole it's way less accurate than a standard hardware sensor. I'd much rather OnePlus either returned to the rear fingerprint sensor or adopted a time-of-flight sensor for 3D facial recognition on the next OnePlus phone.

TREMENDOUS SPEED INSIDE AND OUT

Once you unlock the OnePlus 7, however, you won't have any complaints. The model I tested had a whopping 12GB of RAM, but even if you opted for a more reasonable 6GB or 8GB, the Snapdragon 855 processor will absolutely shred anything you throw at it. To say I didn't experience any lag is to understate just how fast this phone is, thanks in large part to the evolution of Oxygen OS, which has become one of the fastest and cleanest custom Android skins this side of the Pixel.

Oxygen OS 9.5 even has some personality of its own. All of the Android Pie features are here—Digital Wellbeing, gesture navigation, streamlined notification shade—but OnePlus has considered how the user and the features coexist before making any changes. For example, there's a new Zen Mode that goes beyond app timers to force you to take a 20-minute break from using your phone. And when you open the notification shade, a "clear all" icon appears at the bottom of the screen so you can easily reach it.

Gesture navigation is the same as it is on the 6T, which is to say it's not always as intuitive as it could be. Quibbles aside, it's almost as if

The 6.67-inch OnePlus 7 Pro (left) makes the 6.25-inch 6T look downright small.

gestures were specifically designed for the 7 Pro's 90Hz screen. Icons and app screens follow your finger as if you're physically moving them and flicking them away, giving the whole system a fresh, modern feel.

The OnePlus 7 Pro (right) uses a pop-up camera instead of a notch.

At some point Android OEMs are going to have to get on the same page with gesture navigation—even more so now that Google introduced another new gesture method in Android Q (go.pcworld.com/gest)—but the 7 Pro is easily the best gesture phone, even if it doesn't have the smartest implementation. For example, without a virtual home button, Oxygen OS leaves no on-screen method for summoning Google Assistant. OnePlus has built a shortcut into the power button, but you need to know where to find it, because oddly it's turned off by default.

OnePlus also promises that the 7 Pro won't become obsolete when the 8 Pro makes its appearance. Like a Pixel or Android One phone, OnePlus guarantees two years of version upgrades and three years of security updates. (As such, the 6T is already one of the devices on board with the Android Q beta.) Unfortunately, OnePlus phones are on a bi-monthly cycle rather than a monthly one, but six updates a year is still better than what many of its competitors offer.

MISSING FEATURES AREN'T A DEAL-BREAKER

A lot will be written about the OnePlus 7 Pro's lack of wireless charging, and there's no denying that it's a glaring spec sheet omission. Any 2019 phone with a 'pro' surname needs to have wireless charging, especially when even the affordable flagships from Apple and Samsung have it on board.

However, while the lack of Qi charging might be an issue before you buy the OnePlus 7 Pro, it won't be such a big deal afterwards. That's because you won't really need to charge it much at all. The 7 Pro comes with a 4,000mAh battery on board. While that's

The handy alert slider remains on the OnePlus, but you won't find a headphone jack.

somewhat small when compared to the Galaxy S10 5G's 4,500mAh and the Huawei P30 Pro's 4,200mAh batteries, benchmarks showed 10-11 hours of screen-on time. In my real-world use I never ended the day with less than 30 percent battery life remaining.

That's because the OnePlus 7 Pro makes the most of every ounce of juice. It's not just how long it can last—though advanced battery-saving features such as sleep standby optimization go beyond what's offered on other phones—but also how long you'll need to keep it plugged it in. Warp Charge 30, which was previously limited to the McLaren edition of the 6T, can take the 7 Pro from inside the red to more than half full in less than 20 minutes (though you'll have to use the somewhat bulky bundled charger to reach top speed).

Also missing from the OnePlus 7 Pro is IP-rated water resistance. I make that distinction because there's some confusion over how wet you can get the phone. OnePlus's founder Carl Pei posted a video of the 7 Pro being dropped in a bucket of water to demonstrate that it is water resistant to some degree, but also warned against trying the "bucket challenge" at home. You won't find any mention of water resistance on the OnePlus site. So, you probably shouldn't take your 7 Pro into a pool.

While many fans will shrug at the lack of wireless charging and water resistance, it's frustrating that OnePlus is being so stubborn, especially when the rest of the phone is so damn good. Yes, it costs hundreds of dollars less than the iPhone XS Max and Galaxy S10, but a 'pro' phone comes with certain expectations, and the OnePlus 7 Pro comes up a bit short.

The OnePlus 7 Pro (left) handled the colors and the light in the shot almost as well as the Pixel 3 (right), while the 6T struggled with focus.

THREE CAMERAS MAKE A DIFFERENCE

The OnePlus 7 Pro introduces an entirely new camera system that adds a third ultra-wide-angle lens to the dual-camera array introduced with the OnePlus 5. However, it's not just the third lens that's new, if you look at the camera specs:

Main: 48MP, f/1.6, 1.6 µm, OIS/EIS
Telephoto: 8MP, f/2.4, 1.0 µm, OIS
Ultra wide: 16MP, f/2.2, 117 degree FOV

That's a major bump over the 16MP + 20MP setup in the 6T, and you can see the differences before you even snap your first photo. When you launch the Camera app, you'll see two options to the left and right of the "1x" indicator for easy 3x optical zoom and 0.6x ultra-wide shots. That makes it easy to switch quickly among the three lenses without pinching or diving into menus, and if you want more granular control, you need only tap again. It's a fantastic interface and easily one of my favorite camera apps on Android.

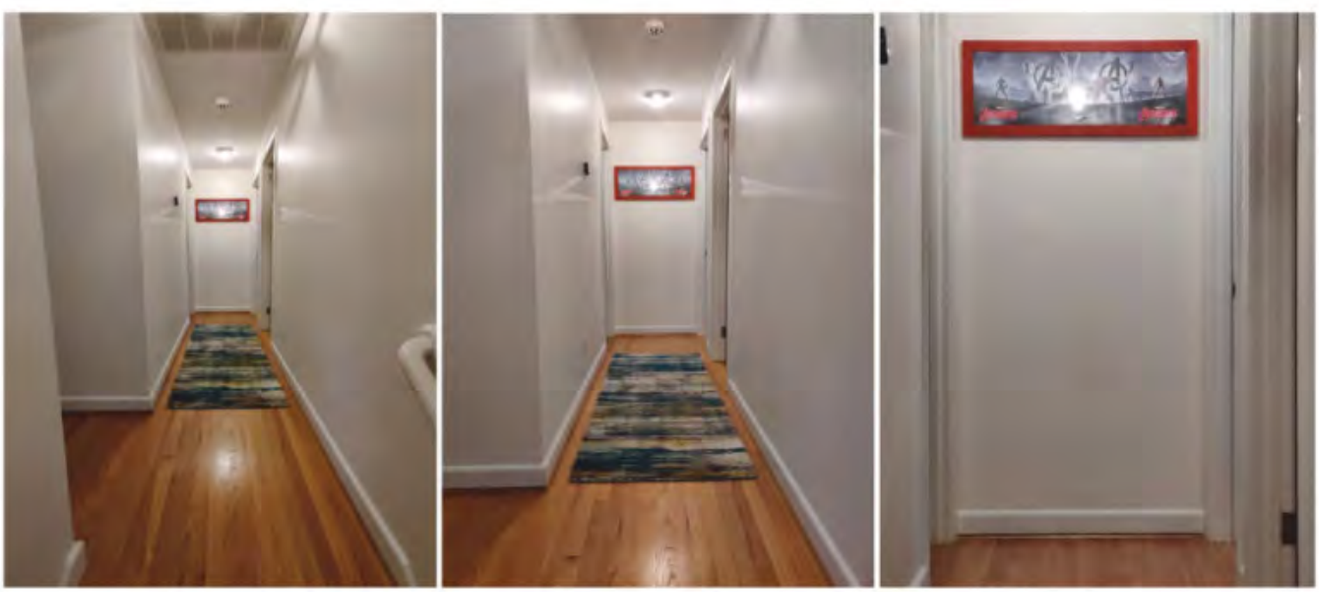
The OnePlus 7 Pro definitely takes better pics than the 6T. In all kinds of light, I captured richer colors, more details, and crisper edges than on any other OnePlus phone. Low-light photos also improved noticeably. Autofocus was super fast and there was very little post-shutter lag, even when using the "nightscape" optimization. In a nutshell: The 6T took mainly OK pics, but the 7 Pro's shots were good and sometimes great.

Funky mechanism aside, the pop-up front camera is basically the same as it is on the 6T, which is to say portraits have blurry edges and some elements are lost to the bokeh effect.

The OnePlus 7 Pro (left) captured more color and detail than the 6T (center) when shooting in low light, but the Pixel 3 was the clear winner.

But like the rear camera, it takes solid selfies.

However, when compared to the Pixel 3, the deficiencies in the OnePlus 7 Pro are stark. Even though the Pixel phones have inferior hardware compared to the OnePlus 7 Pro, Google's post-processing still achieves superior results. For the 8 Pro or whatever comes next, I'd like to see OnePlus work on the computational side of things, because that's where it seems to be falling short.



The telephoto and ultra wide lenses give you an array of options for framing your shot.

The Nebula Blue color of the OnePlus 7 Pro is a beauty.

BOTTOM LINE

Ask yourself these three questions before buying a OnePlus 7 Pro: Do you hate plugging in your phone in to charge it? Do you want to take your phone swimming? Does a top-notch camera matter more than anything else? If you answer yes to any of them, then the OnePlus 7 Pro probably isn't right for you.

Otherwise, it's hard to recommend any other phone. Even if you buy the top-of-the-line 7 Pro with 12GB of RAM and 256GB of storage, it'll only cost you $750, the same price as the iPhone XR and the Galaxy S10e. The OnePlus 7 Pro is superior to those phones in just about every way. The display is remarkable, the design is nearly perfect, and the speed is simply mind-blowing. The camera, while not among the best, is definitely solid.

T-Mobile is again the exclusive U.S. carrier for the OnePlus 7 Pro, but it'll work with any network. I'm a Verizon subscriber and for the first time, I was able to pop in my SIM into a OnePlus phone and immediately start using it without any hiccups or workarounds. That's something that can't be said for most international phones: Anyone can buy an unlocked OnePlus 7 Pro without worrying whether it'll work with their network. And unless they either hate wires or love water, I suspect a lot of would-be Pixel 3 XL and Galaxy S10+ buyers are going to do just that.

OnePlus 7 Pro

★★★★½

PROS

- Gorgeous design with a stunning display.
- Insanely fast with long battery life.
- Pop-up selfie cam is fast and smooth.

CONS

- No wireless charging or water resistance.
- Camera is really good, but not flagship quality.

BOTTOM LINE

OnePlus has flipped the script with its first 2019 phone, the 7 Pro, challenging the high end with a true flagship-quality handset.

$699

Raspberry Pi 3 B+: Better than ever, but limits remain

The Raspberry Pi 3 B+ is a great device, but there are limits to what it can do. **BY IAN PAUL**

The Raspberry Pi mini computer just keeps getting better. It's been three years since we reviewed a major upgrade to the Raspberry Pi line, and it was worth the wait. If you've been wondering if the Raspberry Pi 3 B+ is a worthwhile upgrade let me answer that with an emphatic yes.

Once again, we're seeing a noticeable jump in performance compared to the Raspberry Pi 3 Model B (go.pcworld.com/rpi3) that we looked at in early 2016. Some of the downsides of the Raspberry Pi still exist with the Pi 3 B+. Nevertheless, if you're looking to tinker with hardware, start programming, or just create an everyday PC for

IMAGE: RASPBERRY PI FOUNDATION

very basic needs, the Raspberry Pi 3 B+ is an excellent choice.

Hardware hacking is a major focus of the Raspberry Pi, but as this is *PCWorld* we'll mostly concern ourselves with how Raspberry Pi functions as a PC. That can mean acting as a basic desktop machine, a home theater PC (HTPC), or a tool for learning how to program.

The board we're reviewing here was produced by RS Components and Allied Electronics (go.pcworld.com/rsdl).

THE BASICS

On paper, the hardware for the Pi 3 B+ isn't that different from its predecessor. There isn't any extra RAM, the GPU is the same, and the processor's clock speed made a small jump. And yet, the Pi 3 B+ performs far better than previous boards.

SoC: BCM2837B0 64-bit system-on-chip with four ARM Cortex-A53 CPU cores clocked at 1.4GHz

CPU: 4x ARM Cortex-A53, 1.4GHz

GPU: Broadcom VideoCore IV

RAM: 1GB LPDDR2 SDRAM

Networking: Gigabit ethernet (via USB channel), 2.4GHz and 5GHz 802.11b/g/n/ac Wi-Fi

Bluetooth: Bluetooth 4.2, Bluetooth Low Energy (BLE)

Storage: microSD

GPIO: 40-pin header, populated

Ports: HDMI, 3.5mm analog audio-video jack, four USB 2.0, ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)

The biggest difference between this model and the Pi 3 B is the 200MHz boost in processor speed. This version also adds a shiny new heat spreader, which helps reduce throttling and maintain that speed boost. It also adds a little "chrome" to the board, as does the new shielding around the wireless circuitry (the little metal box with the Raspberry Pi logo on it).

Beyond the speed boost and new look is the same underlying CPU architecture. The RAM also hasn't changed, and here I really think the board is missing something. Perhaps upping the RAM to 2GB has technical or cost issues we're not aware of, but it's high time this board added a little more volatile memory

to the overall package.

The Bluetooth connection gets a point upgrade to 4.2, and the networking capabilities add dual-band Wi-Fi. The ethernet port is also faster, with two to three times better performance over its predecessor, but don't say the "G" word. Raspberry Pi's introductory video (go.pcworld.com/pivd) for the new board says this is not true gigabit ethernet. While the physical component is a gigabit port, it's connected to the board over a single USB 2.0 bridge, limiting the theoretical maximum throughput to 300Mbps.

There are also a few changes that will matter more to hardware hobbyists than anyone looking for a cheap HTPC or retro gaming console. It's Power-over-ethernet ready, but you'll need to buy the HAT module, sold separately. Finally, there's a new power management integrated circuit (PMIC) that replaces the discrete components for a smoother power draw.

Since the introduction of the Raspberry Pi 2 model B in 2015, the RPi has been rocking four USB ports, meaning you can connect a good number of peripherals when necessary. With the Pi 3 B+, however, some users may find that a USB hub with an external power source would be a better option.

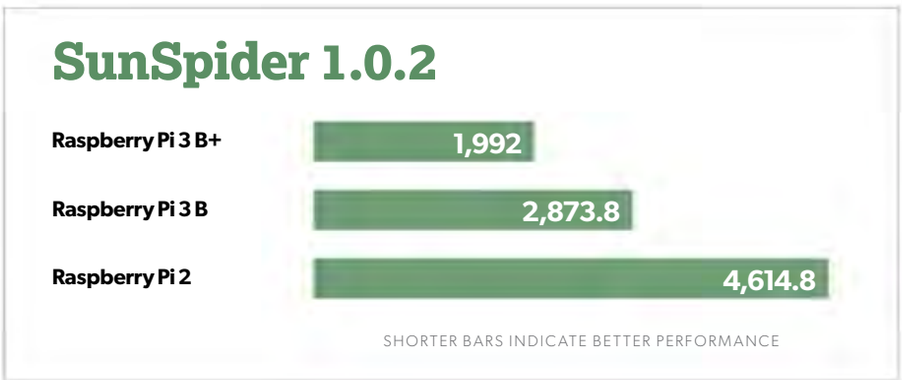
This device is serious about its power needs, and a hub can alleviate that. The days of getting by with whatever old phone or tablet charger you have lying around are long gone. If you don't have a 5V/2.5 amp wall charger, then you aren't going to see the new Pi perform up to snuff—you could even have some issues with data loss. Most phone and tablet chargers output 1 or 2 amps at most, which is simply not enough for the Pi 3 B+.

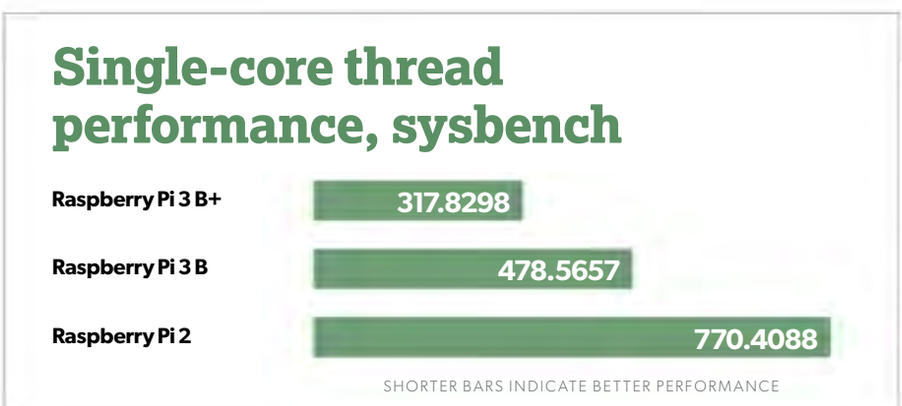
Users on various forums claim that a 5V/2.4 amp charger will get the job done, but we haven't tested that. For our tests, we used a 5V/3.0 amp charger, and it did a fantastic job.

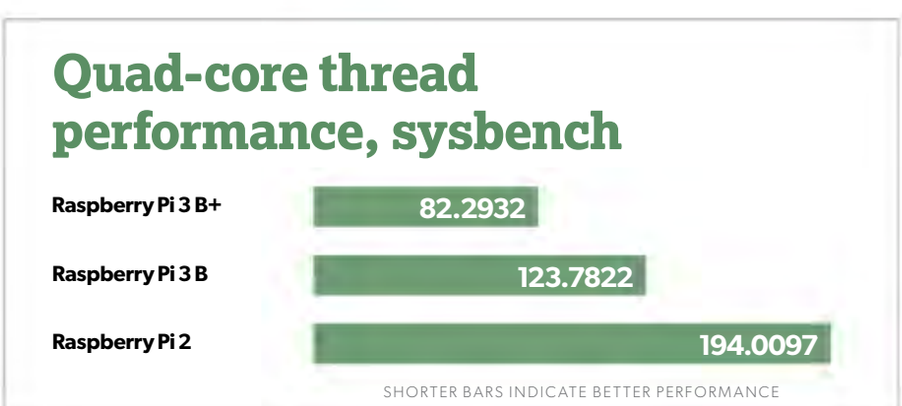
THE BENCHMARKS

We took this board through the usual set of synthetic benchmarks and browser tests to give you a sense of how it performs.

For our tests, we loaded up the Raspberry Pi with the latest version of the Raspbian







Stretch (go.pcworld.com/rspb) build—released in April 2019—at this writing.

Our first benchmark was Sunspider 1.0.2 using the built-in Chromium browser. Last time we tested this JavaScript benchmark with the Epiphany browser, which was the default at the time. Lower results are better in this case, and as you can see the Raspberry Pi 3 B+ smoked its predecessors.

The Octane 2.0 test was a little closer with the Pi B+ only improving upon its predecessor by 352 points. An incremental improvement for an incremental upgrade.

Next up we took a look at the Pi 3 B+ with sysbench. As with our previous tests for Raspberry Pi hardware, we tasked the Pi 3 B+ to calculate all prime numbers between 0 and 20,000 using a single processor thread. The Pi B+ was able to complete the task nearly three minutes faster than its predecessor.

Similarly, when we allowed the mini computer to use all its processing power, it completed the same task in 82.2932 seconds—a full 41 seconds faster than the Pi 3 B.

THE FULL PI

The Raspberry Pi is a powerful little computer for its size and cost, but it takes a lot more than just the board to make a PC. You'll also need a mouse, keyboard, and display to make it all work. On top of that, you'll need a microSD card loaded with the aforementioned Raspbian operating system or another OS such as LibreELEC (go.pcworld.com/lbre) for media streaming or Retropie for classic gaming (go.pcworld.com/rtrp).

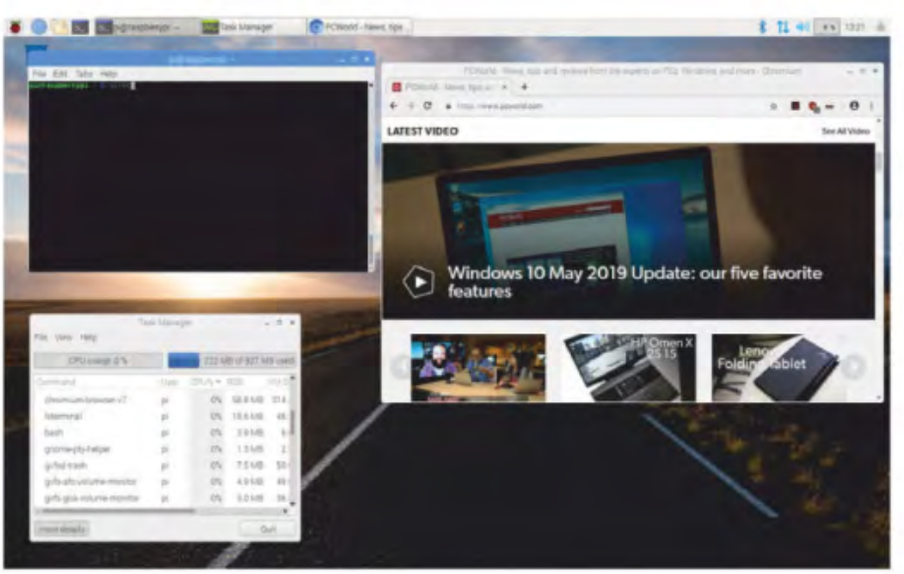
The easiest way to install Raspbian is to use the Noobs (go.pcworld.com/noob) installation tool, alternatively you can flash the Raspbian disc image to a microSD using a third-party app such as Etcher (go.pcworld.com/blet).

Raspbian with the Stretch desktop interface makes the operating system very usable, especially if you choose the version of Raspbian with recommended software. This includes the LibreOffice suite, VLC, a ton of tools to learn and practice programming, the Chromium web browser, and Minecraft Pi Edition.

That said, there are still some issues in day-to-day use with Raspbian. I spotted some unnatural-looking, almost choppy movement in YouTube videos at times. This is a common problem with all Raspberry Pi devices and likely due to its limited power draw. Watching Netflix also isn't an easy achievement on Raspbian. Having multiple browser tabs or windows open at one time can be a real problem, but like video streaming that's to be expected. Playback for local videos is fantastic, however.

Minecraft Pi is very basic, and for what it is it's great; however, if prospective Raspberry Pi users are accustomed to playing on PC (Java or Windows 10) or console, this version will not appeal.

Raspbian also has an app catalog of sorts where you can download and install other



The Raspbian Stretch desktop on a Raspberry Pi 3 B+.

The Raspberry Pi 3 B+ with a full complement of connected peripherals.

programs, but It's not the best experience. The buttons aren't well labeled, and at times they didn't seem to work. A better approach would be to learn how to install programs from the terminal using the built-in package manager, APT. The command line seems scary, but it's fast and easy once you learn the few basic commands needed to get things done.

BOTTOM LINE

For $35, and the addition of a few peripherals many people already have lying around, you can put together a nice little basic-needs PC for the kids, an entertainment console, or a classic gaming machine. I'd highly recommend the Pi 3 B+ for any budding programmer, because it has all the tools necessary to get started.

For elementary and perhaps even middle school students the Raspberry Pi 3 B+ is up to the task as a daily driver for homework and basic web surfing—especially if you buy a case to go with it (go.pcworld.com/rcse). Anyone beyond that age will likely be disappointed with the Raspberry Pi as an everyday desktop.

That's not all a Raspberry Pi can do by any stretch, as we've seen some insanely innovative Pi projects (go.pcworld.com/pipr). Beyond the aforementioned uses, it can also function as a home-based server for everything from Minecraft to chat and home automation.

Raspberry Pi 3 B+

★★★★½

PROS

- Best performing Raspberry Pi yet.
- Improved Ethernet and wireless performance.
- Incredible value for the price.

CONS

- More specific power requirements.
- Limited ability for desktop multitasking.

BOTTOM LINE

The Raspberry Pi model B continues to improve with every release, and the Raspberry Pi 3 B+ is no different. This version of the Pi adds a better processor, improved Ethernet and Wi-Fi, and it's power-over-Ethernet (PoE) ready. We'd like to see this version add a little more RAM, but this is an excellent little mini PC that can even stand in as a quick-and-easy PC solution for young students.

$35

Seagate FireCuda 510 NVMe SSD: Very fast almost all the time

This SSD was scintillantly fast, but dropped to merely good in one test. **BY JON L. JACOBI**

PCWorld EDITORS' CHOICE

Seagate ran some pretty impressive performance numbers by me before I had an actual chance to test the company's new FireCuda 510 NVMe SSD. I'm happy to report that the drive lived up to the hype and then some—except for one test that has us scratching our heads.

FEATURES AND SPECS

The FireCuda 510 is a 2280 (22 mm wide, 80 mm long) M.2 NVMe SSD that can make full use of the x4 PCIe generation 3 (8Gbps). The next generation of 16Gbs PCIe 4.0 products were announced at Computex, which may alter the equation a bit for early adopters and other bleeding-edge NVMe SSD purchasers. Look for an article on that soon.

The FireCuda 510 uses 64-layer 3D TLC (Triple-Level Cell/3-bit) NAND and ships in $230 1TB and $400 2TB flavors. There's 1MB of DRAM cache for every 1TB of memory, and the drive also employs some of the TLC as SLC for secondary caching. Nicely, the drive carries a five-year warranty and is rated for a very generous 1300TBW for every 1000GB of capacity. Any time the TBW (TerraBytes Written) rating exceeds capacity (times 1000), it's a very good thing.

PERFORMANCE

The FireCuda 510 absolutely aced CrystalDiskMark 6 and AS SSD, and did very well in all the copy tests. In fact, it scored the

IMAGE: SEAGATE

The back of the FireCuda 510. Note the chips on both sides.

highest of any drive overall and for writing other than Intel's 905P, a super-expensive Optane drive.

However, there was one slowdown to about 1GBps during the 48GB single file write test that stumped us. This is usually an "Aha! It ran out of cache" moment that's mirrored when we write 450GB to the drive. However, aside from two momentary and less significant dips in speed, the drive never slowed down in the same fashion during the 450GB write tests. Go figure.

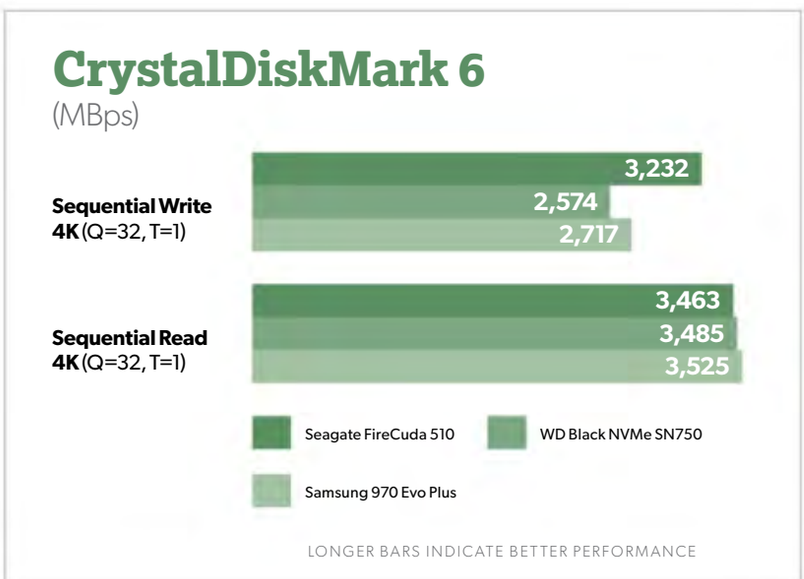
You can see the phenomenon in the two screen caps below the test results. The dark green bars show the FireCuda 510's performance.

AS SSD 2 thinks the FireCuda 510 is a beast (in the good sense), and it is during everyday performance.

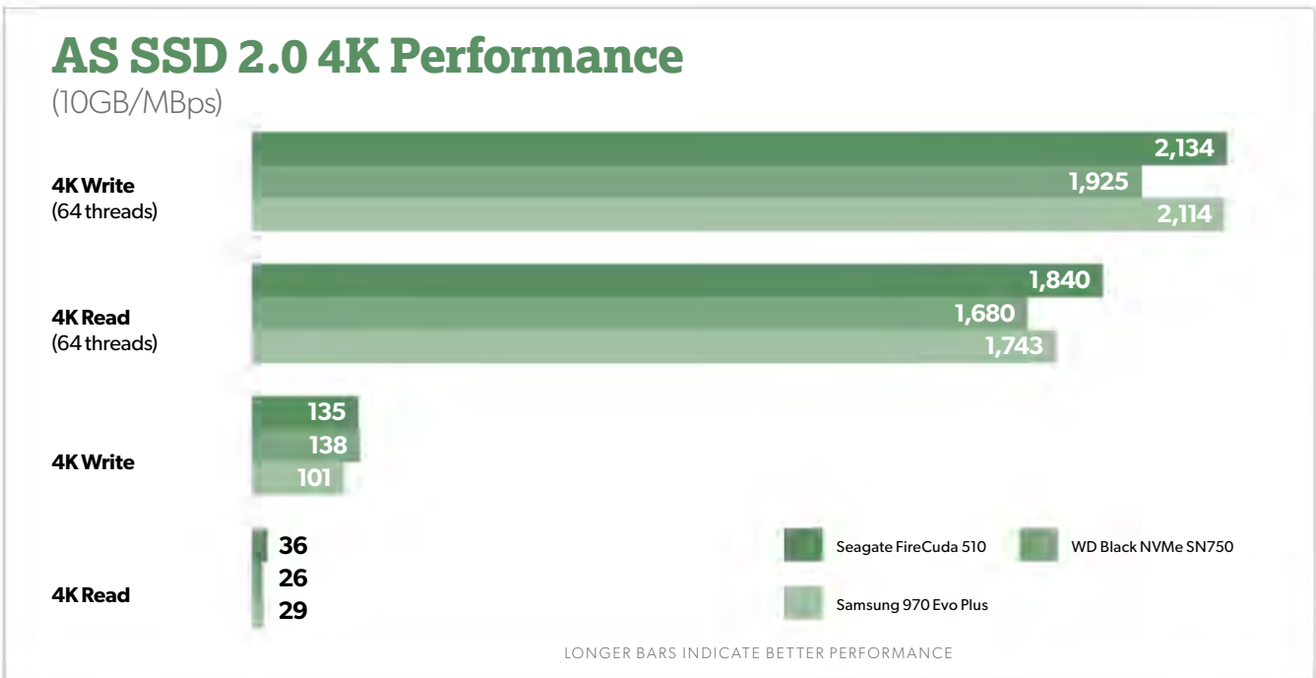
As you'll see below, the FireCuda 510 is better with large groups of small files than with single large files, though it's not too shabby with those either.

The FireCuda 510 dipped to around a 1GBps transfer rate at the 30GB mark during our 48GB single file write. It stayed there, but look at the next screen cap.

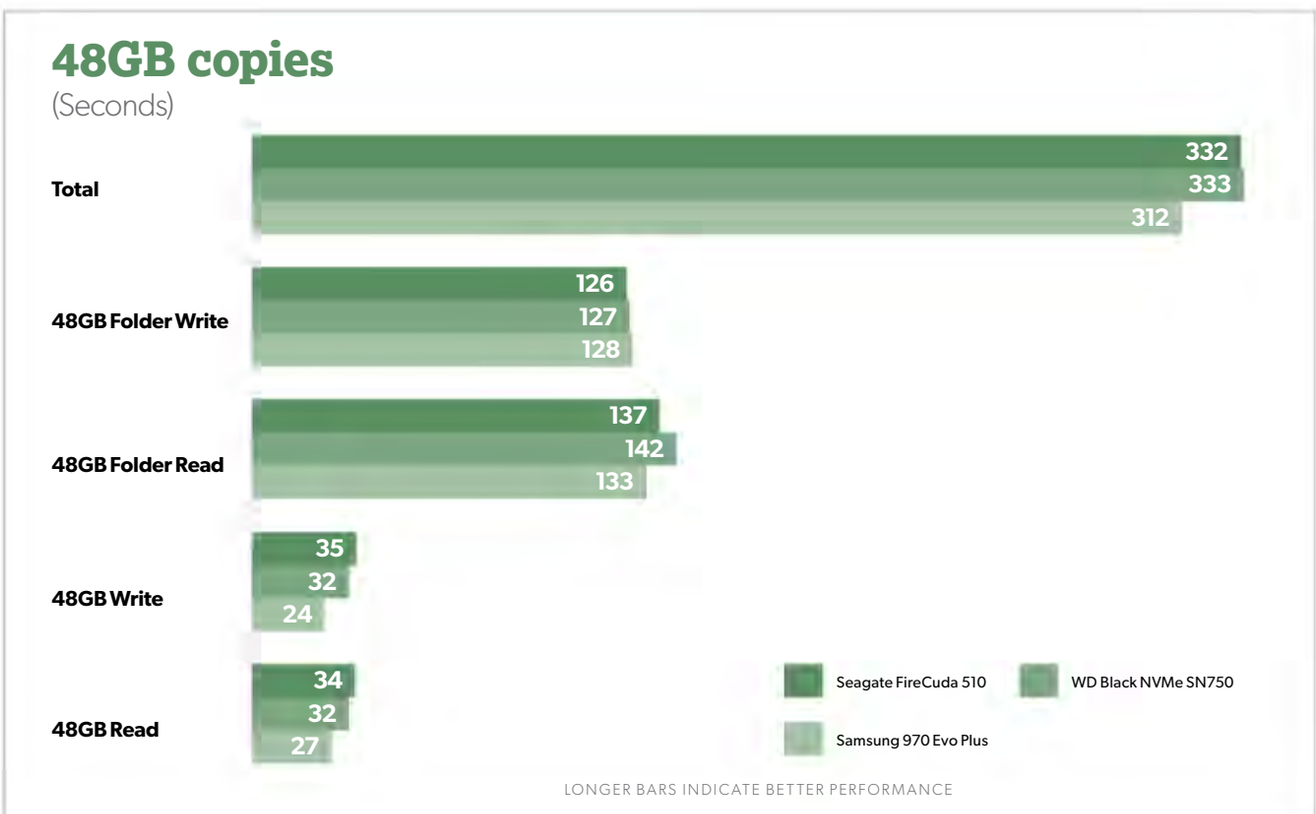
When given an even larger 450GB file to write, FireCuda 510 dipped from its normal 1.8GBps performance only a few



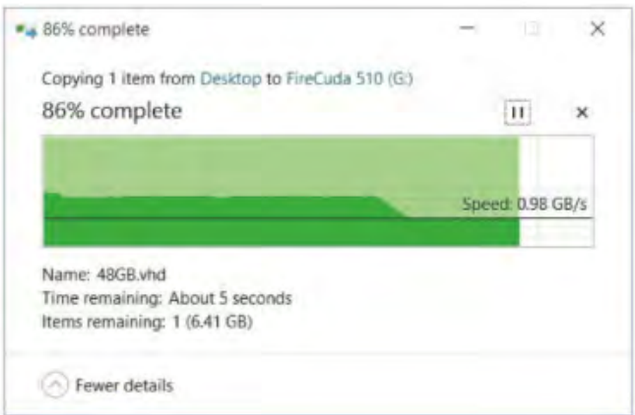
As you can see the Samsung 970 Pro has little on the FireCuda 510 in CrystalDiskMark 6.



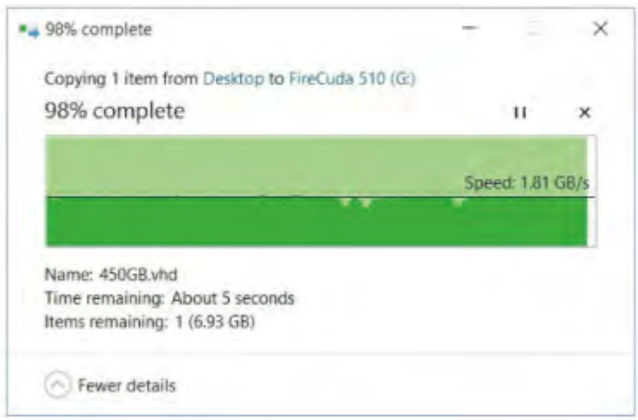
The FireCuda 510 compares well with Samsung's best under AS SSD 2.



Because of a dip in performance at the end of the test, the FireCuda 510 slipped behind it's rivals. Oddly though, the drive didn't dip nearly as early during a 450GB copy test.



We were a bit surprised that the FireCuda 510 dipped to around 1GBps during our 48GB single large file write test. See the image to the right for the reason.



This is the reason that we were surprised with the 48GB single file write test. There are no dips in the 450GB copy test until several hundreds of gigabytes have been written, and they don't appear as severe.

times, but it was much later in the process and not permanently.

My best guess about the performance dips is that Seagate, like other companies, is employing some sort of smart algorithm to determine how much of the TLC should be treated as SLC, or possibly MLC. That is, writing one bit or two bits to the cell rather than the full three each cell may contain. Writing fewer bits means much faster write performance.

Whatever the explanation, while there's a dip in the short copy, I can't say the FireCuda 510 isn't good for long writes. Especially when the few dips there are remain at or above the 1GBps mark.

BOTTOM LINE

For everyday use, the FireCuda 510 is a worthy competitor for the Samsung 970 Pro and especially appealing as it's considerably cheaper. The odd slowdown in the 48GB copy is apparently transitory and not a major concern, especially considering the drive's strong result in our 450GB write,. It's not quite as smooth at the 970 Pro, but close enough. Hence… Highly recommended.

Seagate FireCuda 510 M.2 NVMe

★★★★½

PROS

- Scintillating everyday performance.
- Very affordable.

CONS

- Not as silky-smooth as Samsung's 970 Pro with long writes.

BOTTOM LINE

The Seagate FireCuda 510 performs on a par with the outstanding Samsung 970 Pro the vast majority of the time—for considerably less money. That tells you all you need to know.

$265

Jackery Honda 290 Portable Power Station: Big, powerful, and oh so expensive

If you need a lot of portable power, then boy do we have the power station for you.

BY JASON CIPRIANI

Portable battery packs have become a common accessory for smartphone owners to carry and use on a regular basis. Power stations, like the Honda 290 made by Jackery, however, are starting to get more attention.

The Honda 290 is big, measuring 9.0 x 7.8 x 5.2 inches and weighing 6.6 pounds, but it packs a ton of power. There's a small display where you can view the current

IMAGE: JACKERY

charge level, along with input and output amounts. There's a 12V charging port, two USB ports, and a standard AC port. There's also a single input port, used for charging the power station itself.

Each section of ports has a power button next to it, with a small light that lets you know if that section is currently turned on. For example, if you plug something into a USB port, you have to press the power button for that section. Once the device is charged and you unplug it, you have to press the power button again to turn off that section of ports. It would be nice if each port would time out and turn off if there wasn't any output for, maybe, 15 minutes, but remembering to press a button isn't that big a deal.

The two USB ports are capable of putting out 5V at 2.4A each, while the standard AC adapter will put out 110VAC at up to 200W. The car port puts out 12V with a 42W max.

There's a total of 292Wh capacity in the Honda 290, and when draining the battery from full to empty over 22 hours, I found it to have 90.63 percent efficiency. That's a solid result, and one I honestly didn't expect. There's a fan inside the casing that kicks on when the unit gets hot over time, so that eats into the total Wh available. Although the display turns off after a couple of minutes, it uses a share of the power, as do the power indicator lights for each section of ports.

But I didn't want to only rely on testing its efficiency. Assuming someone would use the Honda 290 in the event of a power outage, I plugged a lamp into it when it had a full charge. The lamp turned off right around six hours of constant use.

Charging the Honda 290 is done via a dedicated input and took 7.5 hours from completely empty to full. There's a solar panel accessory for charging the station, but that's a tough sell given how slow it would be.

The Honda 290 isn't a battery pack you throw in your backpack or suitcase for an overnight trip. It's a backup power supply, that will get you through power outages from storms, or a camping (glamping?) trip over the weekend.

The biggest downside I can find is the price. The Honda 290 is priced at $350—ouch. But for someone who needs portable power that's good for more than just one or two smartphone charges, the Honda 290's got it.

Honda by Jackery 290 Power Station

★★★★½

PROS

- Incredibly efficient.
- Multiple ports, power outputs.

CONS

- It's expensive.

BOTTOM LINE

This isn't your average portable power bank, but rather a burly power station that's ready to oblige in an emergency or on your next road trip.

$349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SAMSUNG GALAXY A50 VS. GOOGLE PIXEL 3A

WHICH MIDRANGE SHOOTER SHOULD YOU BUY?

SAMSUNG HAS LAUNCHED THE MIDRANGE GALAXY A50 IN THE U.S. TO TAKE ON THE GOOGLE PIXEL 3A. **BY MICHAEL SIMON**

IMAGE: GOOGLE/SAMSUNG

As premium smartphones regularly blast through the thousand-dollar threshold, there's a new battle beginning among midrange handsets. In May, Google unveiled the Pixel 3a, which sacrificed speed for stellar photography at an affordable price. Now Samsung is doing the same with its surprise U.S. launch of the Galaxy A50. Let's take a look at how these phones stack up:

SIZE AND DISPLAY

If you're looking for a small phone, the Galaxy A50 isn't it. Where the Pixel 3a comes in two sizes, the A50 has a single 6.4-inch model, which is just as big as the Galaxy S10+. The A50 uses Samsung's Infinity-U display, which includes a notch to contain the front camera and the speaker and rounded corners, while the Pixel 3a has a more traditional forehead for the camera and sensors:

Galaxy A50: 6.4-inch FHD+ 2340 x 1080 AMOLED
Pixel 3a: 15.6 inch FHD+ 2220 x 1080 OLED
Pixel 3a XL: 6-inch FHD+ 2160 x 1080 OLED

However, thanks to a notch at the top of the screen for the front camera and speaker and slim bezels, the A50 is dimensionally smaller than the 3a XL and not much bigger than the 3a:

Galaxy A50: 158.5 x 74.7 x 7.7mm
Pixel 3a: 151.3 x 70.1 x 8.2 mm
Pixel 3a XL: 160.1 x 76.1 x 8.2 mm

The Galaxy A50's 6.4-inch display is just as immersive as the one on the Galaxy S10+.

Design-wise, the Pixel 3a looks very much like the Pixel 3, right down to its two-tone back. The Galaxy A50 isn't quite a Galaxy S10 clone, but it's a good-looking phone for the price. Instead of a hole, it has a notch at the top of the screen for the front camera and speaker. The bezels are visible but very thin, though there is a decent-sized chin at the bottom. Both of the phones are made of plastic, but the A50's shimmery "Prism" paint job gives it a decidedly premium feel.

PROCESSOR AND SPECS

As midrange phones, you'll find specs that are a step below premium, but not bad at all. Here they are:

The Pixel 3a is made of plastic, but it doesn't feel cheap.

Galaxy A50

Processor: Quad 2.3GHz + Quad 1.7GHz
RAM: 4GB
Storage: 64GB

Pixel 3a/3a XL

Processor: Snapdragon 670
RAM: 4GB
Storage: 64GB

Samsung is using the 10nm Exynos 9610 in the A50, which matches up very well with the 14nm Snapdragon 670, which has a quad 2.2GHz and 1.84GHz cores. In benchmarks (go.pcworld.com/bnmk), the two chips perform extremely similarly, and each phone should be able to handle most tasks well, especially with OS and app optimizations. Both phones also include a headphone jack.

The 64GB of storage should be enough for all but the most demanding of users. The A50 also includes an SD card slot (up to 512GB). Like the Pixel 3, the Pixel 3a doesn't include a storage slot.

As far as biometrics go, the Pixel 3a has a standard fingerprint sensor on the rear case, while the A50 includes an optical fingerprint scanner inside the front display. Both phones run their respective versions of Android 9 Pie, and the A50 ships with Samsung's new One UI.

BATTERY AND CHARGING

On paper, the A50 has a big advantage over the Pixel 3a and 3a XL when it comes to battery life:

Galaxy A50: 4,000mAh
Pixel 3a: 13,000mAh
Pixel 3a XL: 3,700mAh

However, capacity doesn't tell the whole story. Google optimizes the heck out of its battery with Android, so real-world use should be roughly the same. Both phones also support fast charging, so when they run out of juice you'll be able to fill them up in less than an hour.

CAMERAS

Both of these phones lean heavily into their cameras, though they couldn't be more different:

Galaxy A50
Front camera: 25MP
Rear camera: 25MP, f/1.7 + 5MP (depth) + 8MP (ultra-wide)

Pixel 3a/3a XL
Front camera: 8MP
Rear camera: 12.2MP, f/1.8

The camera on the Pixel 3a is just as good as the one on the Pixel 3.

To look at them, you'd think the Galaxy A50 runs circles around the Pixel 3a, but hardware has never been the story of the Pixel. Google's post-processing work is among the best in the business, so photos taken with the single-camera Pixel are often better than those shot with multi-camera high-end phones. The Pixel also includes a few cool tricks, including portrait color pop (which lets you isolate your subject against a black-and-white background) and the insanely cool Night Sight low-light camera. The ultra-wide-angle lens on the A50 is definitely a benefit, but if a good camera is your biggest concern, the Pixel 3a might be a better bet.

PRICE AND AVAILABILITY

The Google Pixel 3a is available now through Google.com (go.pcworld.com/by3a) as well as Verizon, T-Mobile, and Sprint stores. The A50 is also available now and is a Verizon exclusive for a limited time:
Galaxy A50:$350
Pixel 3a: $400
Pixel 3a XL: $479

BOTTOM LINE

For the price, you'll be getting a great deal with either of these phones, but the A50's $350 price tag really stands out. You're getting a triple camera, 6.4-inch screen, and giant battery, as well as an expandable storage slot. There's just one huge caveat: Google promises two years of Android updates and three years of security updates, while Samsung offers no such assurances. The Pixel 3a brings an incredible camera system as well. If you want a smaller screen, the Pixel's an easy recommendation, but otherwise the A50's price is hard to ignore.


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PCIe 4

EVERYTHING YOU NEED TO KNOW, FROM CAVEATS TO COMPATIBILITY TO SPECS

IMAGE: ISTOCK

.0

AMD'S NEW RYZEN PLATFORM USHERS IN THE FIRST BIG CHANGES TO PCIE SINCE 2010.

BY GORDON MAH UNG

Come July, AMD gets to hoist the trophy in the race to the next-generation PCIe 4.0 interface for desktop PCs. By combining its upcoming Ryzen 3000 CPUs, Radeon RX 5700 graphics, X570 chipset, and a new spate of PCIe 4.0 SSDs, consumers will be able to build or buy the first PCIe 4.0-based PC.

PCIe 4.0 sounds exciting—it's the first big change to the interface since 2010. But as always, the questions of who can get it (and who can't), and who really needs it, are more nuanced than you'd think. Keep reading to get the all the details.

WHAT IS PCIE 4.0?

PCIe 4.0 is the next iteration of the PCIe interface. It's used for connecting add-in cards and M.2 drives, as well as interconnecting various chips inside a PC. Compared to its predecessor PCIe 3.0, PCIe 4.0 essentially doubles the overall throughput. The chart below from PCI-SIG lays it all out nicely:

If that looks like a boatload of bandwidth, it is. Seizing an opportunity to troll Intel and Nvidia, AMD ran Futuremark's unreleased PCIe feature test to show how a Ryzen 7 3800X coupled with a Radeon RX 5700 in PCIe 4.0 mode offered 69 percent more PCIe throughput performance than a Core i9-9900K and GeForce RTX 2080 Ti.

REALITY VS. HYPE

One problem with AMD's demonstration, however, is that "69 percent" performance, while most likely real, probably doesn't actually translate into more practical gaming performance today. That's because few games ever saturate the 32GBps of data today's x16 PCIe 3.0 slot can carry.

This disparity between demand and supply has been proven out many times over the years. Alienware's laptops actually limit the slot to x8 PCIe 3.0, siphoning off the rest to support the external graphics port. The reason? It doesn't matter (much).

AMD's demo featured Futuremark's new PCIe feature test. It showed a PCIe 4.0-based Radeon RX 5700 besting a PCIe 3.0 GeForce RTX 2080 Ti in transfer performance.

PCIE VERSIONS

	RAW BIT RATE	LINK BW	BW/LANE/WAY	TOTAL BW X16
PCIe 1.x	2.5GT/s	2Gb/s	250MB/s	8GB/s
PCIe 2.x	5GT/s	4Gb/s	500MB/s	16GB/s
PCIe 3.x	8GT/s	8Gb/s	1GB/s	32GB/s
PCIe 4.0	16GT/s	16Gb/s	2GB/s	64GB/s
PCIe 5.0	32GT/s	32Gb/s	4GB/s	12GB/s

STORAGE

PCIe promises a huge boost in other areas of the PC, though. The most obvious one is storage, where AMD also demonstrated the performance difference using SSDs.

We witnessed a single Gigabyte Aorus M.2 PCIe 4.0 SSD hitting 5GBps reads and 4.3GBps write speeds. That's about 35 percent higher sequential performance than we've seen from some of the faster M.2 PCIe 3.0 SSDs.

It gets even crazier if you run them in RAID 0, which is what Gigabyte did using a PCIe 4.0 add-in card holding four 2TB PCIe 4.0 M.2 SSDs. You can see the card below with its shroud off. The card is essentially one big passive PCIe extender.

The performance of that card is impressive, at 15.4GBps reads and 15.5GBps writes. Compare that to Intel's VROC demo from the Computex 2017 (go.pcworld.com/dm17), which used eight M.2 x4 PCIe 3.0 drives in RAID 0 on an X299 motherboard. That hit only 11.6GBps.

CRYSTALDISKMARK 6.0.1 X64

	READ (MB/S)	WRITE (MB/S)
Seq Q32T1	5014.4	4266
4KiB Q8T8	1812.7	2058.6
4KiB Q32T1	726.1	698.7
4KiB Q1T1	62.31	238.7

A Gigabyte M.2 PCIe 4.0 SSD can push 5GBps reads and 4.3GBps writes, a hefty increase over PCIe 3.0 drives.

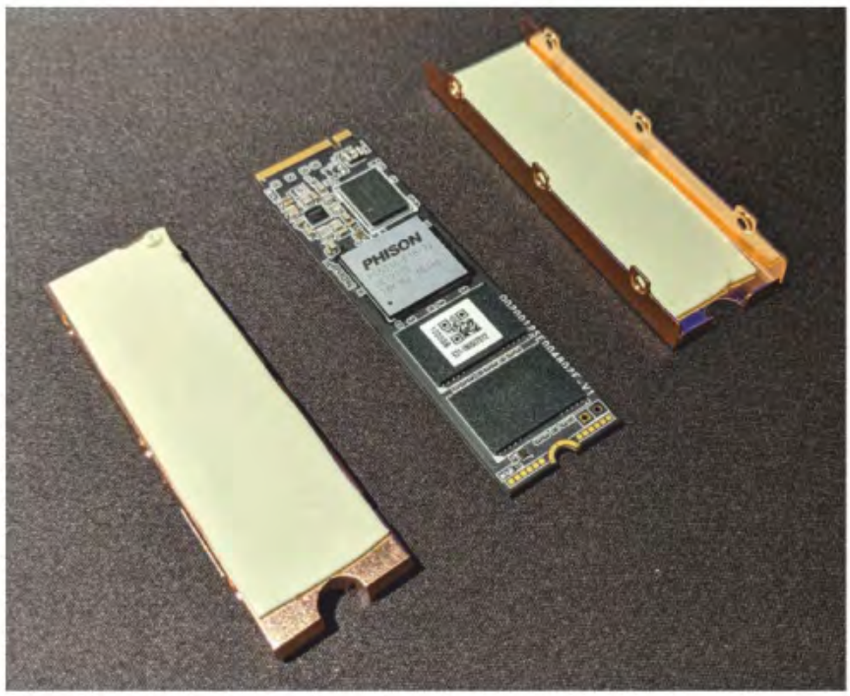
CRYSTALDISKMARK 6.0.2 X64

	READ (MB/S)	WRITE (MB/S)
Seq Q32T1	15385	15509
4KiB Q8T8	2128.3	1826.4
4KiB Q32T1	2056	1742.9
4KiB Q1T1	112.5	143.9

With four M.2 PCIe 4.0 drives in RAID 0, the AMD-based Gigabyte Aorus M.2 RAID card can push 15GB each way.

SSD VS. GPU

While seeing 15.4GBps of drive speed is cool, one thing you should keep in mind is that it will involve a small compromise. Note that the card above is a x16 PCIe 4.0 card. Because Ryzen 3000 "only" can support a single-slot x16 PCIe 4.0, you have to choose whether to put your x16 PCIe 4.0 graphics card or your x16 PCIe 4.0 SSD in that slot.



The Gigabyte Aorus PCIe 4.0 SSD features beefy copper heat sinks, and it needs them.

Maybe you've seen marketing and stories that claim the Ryzen 3000 has 40 PCIe lanes, so "there's plenty." It doesn't quite work out that way.

Unlike a Ryzen Threadripper, which has 64 PCIe lanes (Gen 3.0) in the CPU, the Ryzen 3000's 40 lanes are platform lanes. That means there are 24 in the CPU, with 16 reserved for an add-in card (typically the GPU), and another four for an M.2 or other device. The last four PCIe lanes are used to connect the CPU to the chipset. The chipset itself contains another 16 PCIe 4.0 lanes.

Obviously, you can't squeeze the bandwidth from 16 PCIe 4.0 lanes through four PCIe 4.0 lanes to the CPU, so any 16-lane device running through the chipset's southbridge would be limited. Intel has done the same for its small-socket Core chips.

There is an actual use for these additional PCIe lanes in the southbridge, as they allow motherboard makers to connect multiple M.2 SSD slots, PCIe, SATA, and other ports and devices without having to turn things off—something that was done in the past when they ran out of PCIe bandwidth.

Although we don't know the final configurations of how x570 can be split out, early indications suggest the southbridge can be configured with a single x4 and three x1 slots at PCIe 4.0, with the rest being broken out among other hardware in the motherboard.

While you might recoil at the idea of putting your x16 GPU into a x4 slot shared with other devices, you'll likely take a small

and relatively painless hit, given that it's still the equal of a x8 PCIe 3.0 connection.

PCIE 4.0 WILL RUN HOT

Heat will be a challenge for PCIe 4.0. With the move from PCIe 2.0 to PCIe 3.0, a considerable amount of performance was squeezed out of it by increasing the efficiency of the protocol. With PCIe 3.0 to PCIe 4.0, most of the performance comes from increased clock rate, which brings more heat—so much that the fancy heat sinks aren't just fashion statements, but necessity to maintain performance.

The chipset to supply the PCIe 4.0 is hotter, too. Vendors tell us it'll generate anywhere from 11 watts (at idle, most likely) to 16 watts of heat. It's hot enough that just about every PCIe 4.0 motherboard we've seen featured a fan for the chipset. Fans on southbridge chips were actually fairly common just 10 years ago as well.

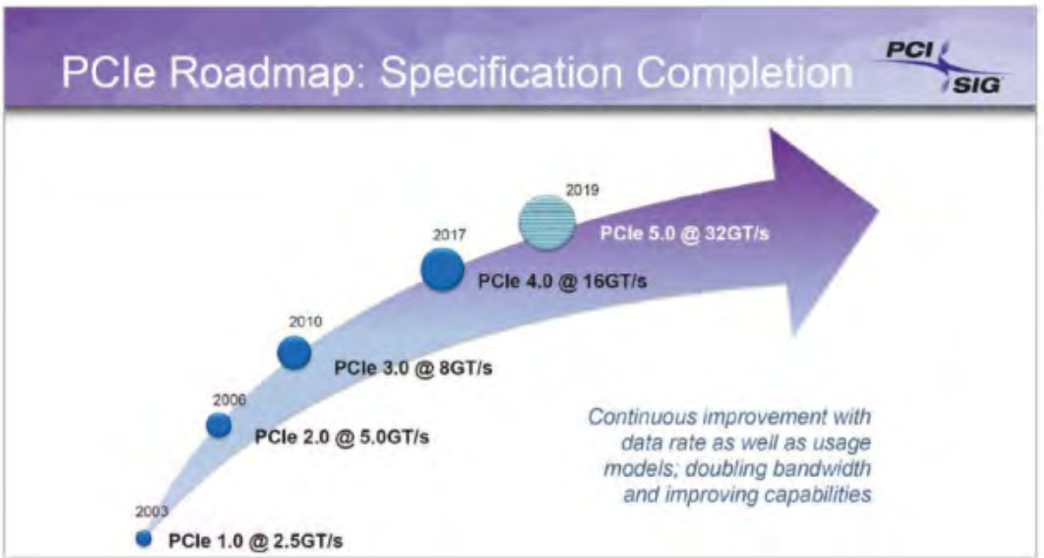
This is a consideration but likely not a concern. Fans do add to system noise, but if done properly, you'll be hard-pressed to hear it.

PCIE 4.0 IS NOT BACKWARD-COMPATIBLE

Initially, AMD fans were juiced to hear that PCIe 4.0 compatibility could be done on older x470 motherboards. In fact, Gigabyte released a UEFI update that appeared to show an older x470 going from PCIe 3.0 to PCIe 4.0.

AMD officially dumped a bucket of cold water on that idea. "PCIe 4.0 will not be supported on motherboards released prior to the X570, so 400-series and 300-series will have PCIe 3.0 support," an AMD spokesperson told *PCWorld*. "These boards were designed and built prior to the capability to ensure PCIe 4.0 functionality, and we cannot adequately ensure a performant, stable user experience. We do not believe this is an acceptable experience for our consumers."

One Reddit user had high hopes after a Gigabyte BIOS/UEFI update seemed to enable PCIe 4.0 support on older AMD motherboards.



It's taken almost two years to see our first PCIe 4.0 hardware. You'll likely see a similar time frame for PCIe 5.0.

WHAT ABOUT PCIE 5.0?

Confusing the news around PCIe 4.0 was the seemingly simultaneous release of the PCIe 5.0 spec (go.pcworld.com/pci5), finalized by the PCI SIG. The confusion is somewhat false, because announcing a spec doesn't mean the hardware is available. The PCIe 4.0 spec was finalized in 2017, and now, about two years later, we have the first PCIe 4.0 hardware. We're likely to see the same lag between final specifications and released hardware for PCIe 5.0.

INTEL DOESN'T HAVE PCIE 4.0 YET

The only thing that could usher in PCIe 5.0 faster than expected is if Intel or Nvidia decided to accelerate its adoption to throw some mud on AMD. Officially, however, Intel hasn't even announced any plans to implement PCIe 4.0, let alone PCIe 5.0. Its current products remain rooted in PCIe 3.0.

PCIE 4.0 WILL QUIETLY BRING MORE SPEED

The move to PCIe 4.0 is, overall, a good move for the PC, removing a bottleneck for ever-faster components down the road. Just remember that these interface ships are hard to turn. The PCIe 4.0 interface, and parts that can take advantage of it, are just beginning to come out.

So while we wouldn't say no to PCIe 4.0 in a new system or build—we'd also have to seriously weigh whether it makes sense to pay extra cash for the feature. For example, does it make sense to pay $250 for a PCIe 4.0-based X570 motherboard, or save $100 and buy a PCIe 3.0-based X470 motherboard instead?

Ultimately, that's the user's choice.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How to get Windows 10 cheap (or even for free)

Yes, you can get a properly activated version of Windows 10 for free. **BY ALAINA YEE**

Windows 10 licenses are expensive—almost painfully so. Shelling out $139 for Windows 10 Home or $200 for Windows 10 Pro feels rough when Linux is free and Windows 7 still hasn't been completely put down. That amount of cash can easily be a third of a budget PC build.

But with less developer support for Linux and the end-of-life deadline rapidly approaching for Windows 7, Windows 10 is an inescapable necessity for most of us. What's not a given is paying full retail.

Yes, it's possible to snag a discount on

VIDEO: **HOW TO GET WINDOWS 10 CHEAP (OR EVEN FOR FREE)**
Watch now at go.pcworld.com/sva

IMAGE: MICROSOFT

Windows 10. The amount you'll save depends on how much hassle you can tolerate—as well as your circumstances. If you're lucky, you could technically get Windows 10 for free. (Legitimately for free, because installing Windows 10 without ever activating it doesn't quite count as getting a full, sanctioned copy of Windows.)

PACKRAT'S LOOPHOLE: TRY A WINDOWS 7 OR 8 KEY

Price: Free

If you have an old Windows 7 or Windows 8 PC lying around, you may still be able to reuse its key to activate Windows 10. When Microsoft first launched Windows 10 back in 2015, it offered Windows 7 and Windows 8 users a truly free, no-strings upgrade to the new operating system. The promotion was only available for just one year—presumably to accelerate push-up Windows 10 adoption rates—and expired in July 2016 (go.pcworld.com/10fq).

But even though Microsoft officially ended this program three years ago, it still has yet to completely shut everything down. The activation servers have been allowing Windows 7 and 8 keys on some Windows 10 installs.

The Windows 7 or Windows 8 product keys that commonly work for this method are the retail and OEM varieties, while only sporadic reports exist for volume license keys (i.e., enterprise or educational licenses) working with this loophole.

While there's no exact science for what works, the following guidelines take into account various data points floating around in articles, forums, and Reddit. First off, you're limited to using keys for a specific version of Windows 7 or 8 with the equivalent in Windows 10. If you have a Windows 7 or 8 Home license, that will only work for Windows 10 Home, and Windows 7 or 8 Pro only work for Windows 10 Pro.

An additional rule of thumb is that you may need a retail product key if you're doing a clean install of Windows 10 on a new computer. OEM product keys should work if you're doing an upgrade or clean install of Windows 10 on the machine the Windows 7 or 8 license is tied to.

If you don't have your license key easily accessible, you can find it by using a program

like Magical Jelly Bean Product KeyFinder. (You can read our step-by-step guide for how to use that particular program at go.pcworld.com/mgcl.)

Once you have that on hand, you'll enter it one of two ways: Either when prompted during the installation process if you're doing a clean install, or through the Change Product Key option in the Activation section of Windows 10's settings.

If the product key is recognized, you'll be issued a digital license that associates your machine with the key, so you should be good to go for the future if this method ever expires, as Microsoft had previously said it would.

EASIEST DISCOUNT: AN OEM LICENSE

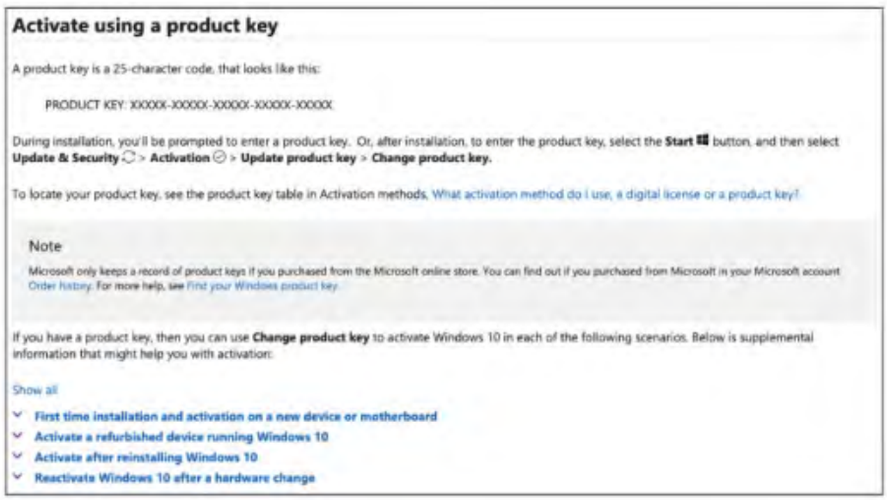
Price: $110 (Windows 10 Home), $150 (Windows 10 Pro)

Our next suggestion is a method that's available to everyone and has the least amount of hassle: Purchasing an OEM license.

License types are different than operating system versions: They dictate what you can do with the software, while OS versions are distinguished by the features available. Multiple Windows license types exist, but the two commonly available to a home user are the retail and

If using a Windows 7 or 8 key works for activation, a digital license will be issued to you.

OEM varieties. When you walk into a store or pop over to Microsoft's website, handing over that $139 for Windows 10 Home (or $200 for Windows 10 Pro) gets you the retail license. If you visit an online retailer like Amazon (go.pcworld.com/am10) or Newegg (go.pcworld.com/ne10), you can find both retail and OEM licenses for sale. You can usually spot an OEM license by its price, which tends to run about $110 for a Windows 10 Home license and $150 for a Windows 10 Pro license.



The process for activating a Windows 10 OEM license (go.pcworld.com/aw10) is the same as for a retail license.

All the features of the operating system version are the same for both license types. The difference is that with a retail license, you can transfer the license key to a different PC later on.

You can't do that with an OEM license. In exchange for a lower price, you get to use the license key on only one PC, period. If you build a system but roll a new one four years later, you can't transfer the license (go.pcworld.com/reac) to the new machine.

Also, if the hardware used to identify your system fails—namely, the motherboard—Microsoft's registration servers won't recognize your license as valid after you replace the dead part. Microsoft has historically been kind about such situations, however; you can usually call to reactivate the license after replacing a fried mobo. But it is an extra hassle.

For further savings, you'll have to wait for the rare sale or Black Friday, when you can get an OEM license in the neighborhood of $85 (Windows 10 Home) to $120 (Windows 10 Pro). Otherwise, if you want to shave down costs further, it's going to take work—or a deep locus of calm when your associates criticize your life choices. (Skip down to "Low prices with a caveat" for details.)

DEEPEST SAVINGS: THE EDUCATION DISCOUNT

Price: $0 to $15 (Windows 10 Education)

Not all student discounts are reserved for the under-24 set. Your local community college might be a source for a free or

extremely discounted copy of Windows 10—and it's nearly the equivalent of Windows 10 Enterprise, to boot. You'll just have to put in some legwork (perhaps literally) to get it.

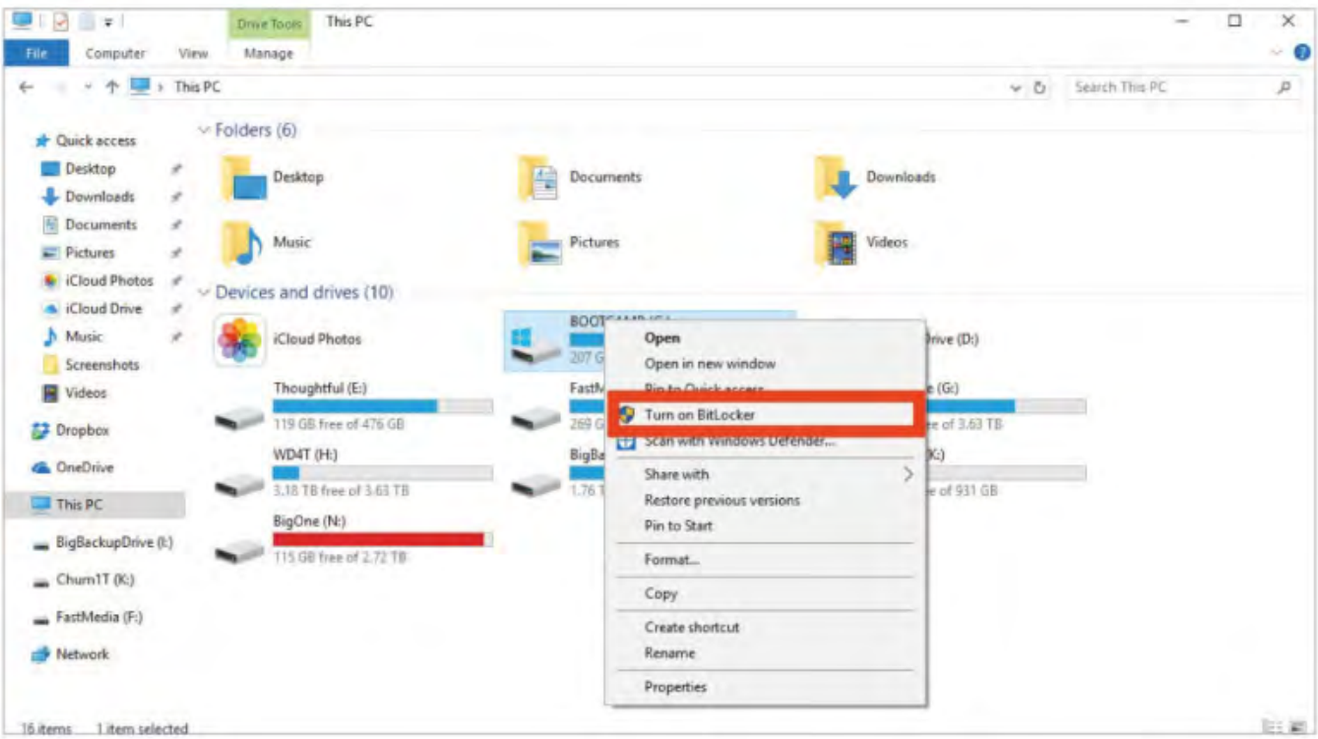
As mentioned above, license types determine what you can do with Windows—and who can use it, as well. Through the Academic Volume Licensing agreements, schools can purchase access to Windows 10 Education for their students, faculty, and staff. Some make it available only on campus machines. Others will grant a license for use on a home machine.

In that latter camp are a number of community colleges, and they often make the Windows 10 license free or supremely affordable (usually $15). The catch: You have to sign up for at least one course to qualify for campus discounts.

To get access to the software, you'll typically need to register for your class first, then find and register separately at whatever online store your campus uses for software purchases. (Many community colleges use OnTheHub as their distributor, so you can use their lookup tool (go.pcworld.com/lkup) to begin research about your school's options.) The storefront will require verification of your student status before you can "buy" Windows 10.

A one-unit class suffices, though, and depending on your state, it costs as little as $76 including administrative fees. Typical

For California's community colleges, CollegeBuys (go.pcworld.com/clby) is the vendor through which you'll "buy" Windows 10. Other states use OnTheHub (go.pcworld.com/othb), which has a tool to look up your school.



Windows 10 Pro's Bitlocker feature makes encrypting a drive very easy.

options are usually of the physical education or dance variety (swim, ballet, jazz, boot camp workouts, etc.), but you can also find the occasional class on topics like Beginning Drawing, Intro to HTML & CSS, and Video for the Web.

If you were already planning on taking a class in one of these subjects, you're getting an amazing deal. Windows 10 Education, which is similar to the enterprise version of Windows 10, includes popular Windows 10 Pro features like Bitlocker encryption (go.pcworld.com/btlk) and the Windows 10 May Update's Sandbox feature (go.pcworld.com/snbx). You're essentially getting Windows 10 Pro (and then some) for as much as 60 percent off and you get to learn something new.

Even if you aren't interested in the classes, you're still paying considerably less than what you would for even a Windows 10 Pro OEM license. We don't encourage truancy, but there's nothing saying you have to show up for class, so long as you're comfortable with a failing grade on your record.

Obviously, if your local community college doesn't have an agreement with Microsoft in place, this strategy won't work. Also, if the total cost of the class, administrative fees, and license fee adds up to more than the retail cost of a Windows 10 Pro license, and you wouldn't have otherwise taken the class, that negates this

deal, too. In those cases, your main options are the OEM license (outlined above) or buying through Kinguin (detailed below).

Note: If you use this method, also keep an eye out for other software deals through your school. For example, your school might offer a free Microsoft 365 account, or a heavily discounted Adobe Creative Cloud account (usually $20/mo).

LOW PRICES WITH A CAVEAT: KINGUIN

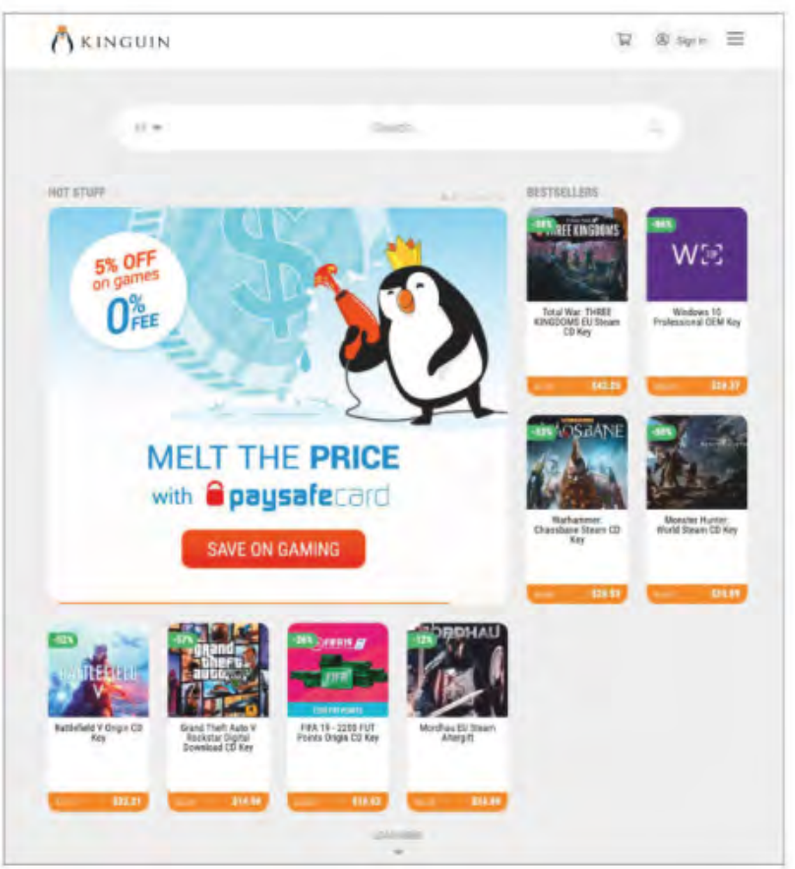
Price: $33 (Windows 10 Home), $35 (Windows 10 Pro)

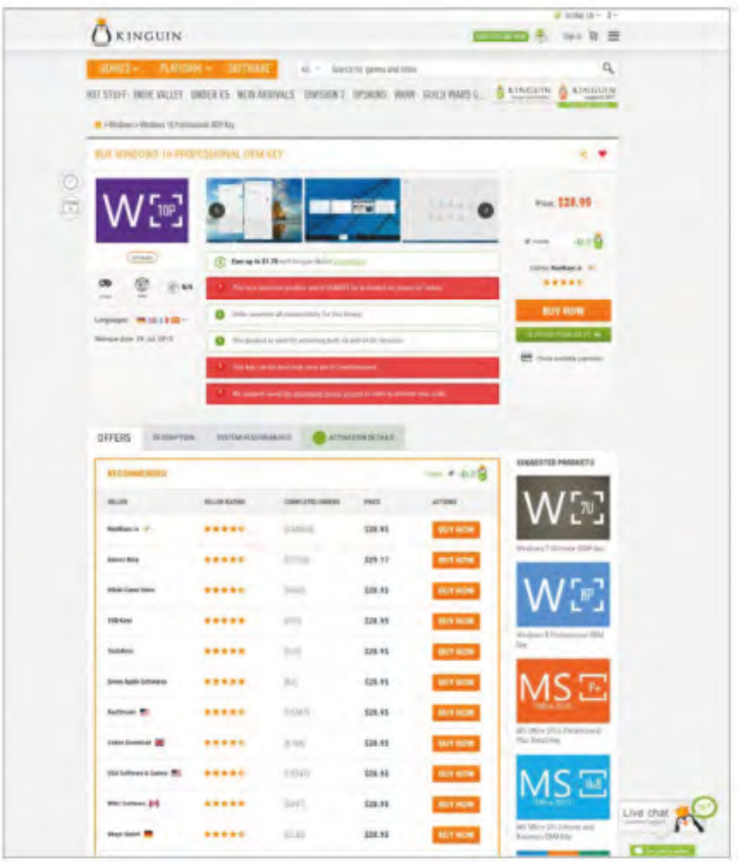
Scoring Windows 10 at an 85 percent discount isn't too good to be true, but this surprisingly low-hassle approach comes with a large dose of controversy.

Kinguin (go.pcworld.com/kgin) is a website that allows buyers to purchase product keys from third-party sellers—think of it like an eBay or Amazon Marketplace for digital software sales. To buy Windows 10, you'll look through the Windows 10 Home OEM or Windows 10 Pro OEM listings, pick a seller's product to add to your cart, and then check out. It's the same as any other digital storefront.

What makes the license keys so cheap—and opinions about buying through Kinguin so fierce—is that they're gray market at best. In other words, while not illegal, they're likely extra keys from a volume licensing agreement that were never meant to be sold individually to home users. Opponents of Kinguin swear the keys will eventually lose their activation status because of their unknown origins.

These keys are also for an OEM license of Windows 10, which means they're meant for only one PC to use at one time. So as mentioned above, if these keys are already somehow tied to an original (but unactivated) PC, things could go sideways during your own activation process.



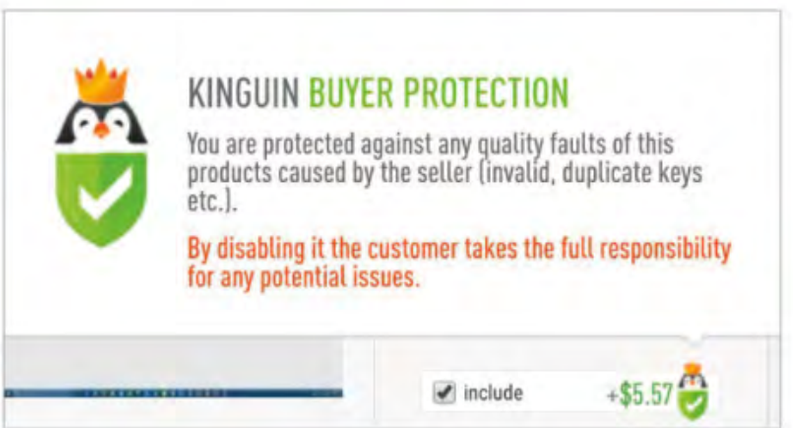


On Kinguin, like on Amazon Marketplace, you pick a specific seller from which to buy the product (in this case, the Windows 10 license key).

Additionally, if you want to transfer the license to a different PC down the road, you can't. On top of that, if the hardware used to identify your system (i.e., the motherboard) bites the dust and you replace it, Microsoft's registration servers won't recognize your system and automatically activate the key. Though Microsoft has historically gone easy on home PC builders caught in this situation, their goodwill may be harder to rely upon if you can't prove that you directly purchased an OEM license from an authorized retailer.

Proponents of this method counter that buying Kinguin's Buyer Protection (go.pcworld.com/kbyp; currently an additional $5.57, and included in the price listed above) covers you in sticky situations with bad sellers and eliminates the risk of troubles. In our office, staff members who've advocated this method of obtaining Windows 10 for years have reported no problems so far.

Each camp makes valid arguments, so ultimately, your comfort level with risk and gray market goods should determine whether this is the option for you. If you opt for this path, we recommend ignoring Windows 10 Home. An extra $2 for the Pro license nets you Bitlocker encryption and other Pro features, which are more than worth it.



Kinguin's Buyer Protection works like eBay's: If anything goes wrong with your purchase, you're covered. It's a must if you buy a license key through them.

Who should buy Intel's 10th-gen CPU in a laptop: Five reasons for and against

For some people, an existing 8th-gen laptop will be just fine. **BY GORDON MAH UNG**

With Intel's 10th-generation Ice Lake CPU (go.pcworld.com/lake) finally here, you may be wondering whether to wait for laptops to come out with the new CPU, rather than buy an existing model with an 8th-gen CPU (Note: Intel's 8th generation offers a full range of mobile CPUs, while the 9th generation offers only high-end 'H' mobile parts). We'll walk you through the reasons why you'd want to wait for a 10th-gen laptop, and five reasons why you don't have to.

FIVE REASONS YOU SHOULD WAIT FOR INTEL'S 10TH-GEN ICE LAKE CPU IN YOUR NEXT LAPTOP

We know, you want shiny new things. And you know what? The shiny new things in laptops

IMAGE: INTEL

are Intel's new 10th-gen chips. Here are five reasons why it would be worth it to wait.

1. THE 10TH GENERATION IS ACTUALLY NEW

With its 10th-generation CPU, Intel moves to a 10nm process. This has been a long time coming: Intel's chip architecture has been stuck on 14nm since 2015's Sky Lake 6th generation. In this image from Intel (go.pcworld.com/img), the company shows the 6th-gen Sky Lake chip as the last major advance, tacitly admitting that 7th-gen, 8th-gen, and 9th-gen CPUs were rehashes to some degree (even though each brought some incremental advances, especially the 8th generation). If you like to latch on to the newest thing, Intel's 10th-gen Ice Lake chips are it.

2. 10TH GEN IS GOING TO BE FASTER FOR APPLICATIONS

The Sunny Cove cores in the 10th-gen chips are "faster, wider" (according to Intel) and basically increase the IPC (instructions per clock) by roughly 18 percent over the cores used in the previous 8th-gen chips. Add to that a new Dynamic Tuning 2.0 feature that more efficiently manages the Turbo Boost capability, and the 10th-gen chips are easily going to outpace previous chips despite running at slightly lower clock speeds.

3. 10TH-GEN CHIPS WILL HAVE THUNDERBOLT 3 AND WI-FI 6

In one of the biggest integrations since Intel stuffed graphics into the 2nd-gen Sandy Bridge CPUs, Intel said it has included Thunderbolt 3 in its 10th-gen CPUs. This hasn't been the case up to now: Thunderbolt 3 support has been an option available to laptop makers via a discrete Thunderbolt 3 controller from Intel. With 10th-gen chips, users get the feature, while PC makers save on cost and space inside the laptop.

The other real nice icing on the cake is that 10th-gen laptops will likely all have Wi-Fi 6, the wireless networking standard formerly known as 802.11ax. As our *Macworld* colleague Jason Cross writes in his Wi-Fi 6 explainer (go.pcworld.com/6wfi), the new standard should give you much faster speeds at 2.4GHz, with better juggling of multiple devices. It supports the 5GHz operating frequency as well. If you're going to build out your home with a new Wi-Fi 6 router system, you'll feel pretty burned with your pathetic Wi-Fi 5 laptop that can't use it.

4. 10TH-GEN FINALLY SUPPORTS FASTER (AND MORE) MEMORY

A very welcome change with Intel's 10th-gen chips is support for LPDDR4X RAM. The obvious improvement is about 50 percent

more memory bandwidth, which will aid everything from application performance (a little) to games (a lot).

The other real benefit will be the amount of memory. The current LPDDR3 memory limits both memory bandwidth and memory amount—laptops that use it max out at 16GB of RAM. While that's plenty for most people, those editing photos or using large memory-footprint applications will finally be able to add more RAM with the move to LPDDR4X.

Intel's Gen11 graphics cores offer significantly better performance than the previous graphics cores.

5. 10TH GEN WILL BE SIGNIFICANTLY FASTER FOR GAMING

Intel's integrated graphics have been the butt of gamer's jokes for years, but the reworked graphics cores in the 10th-gen chips take a big step forward. Intel says the new Gen11 graphics in the 10th-gen CPUs can hit 1 teraflop of performance and is capable of 1080p gaming. With its support for VESA Adaptive Sync, gaming on 10th-gen parts should be far smoother, too.

Laptops also won't need embedded DRAM to get the highest graphics performance. Intel says Gen11 can outperform previous Iris Plus graphics without the use of eDRAM.

FIVE REASONS YOU DON'T HAVE TO WAIT FOR INTEL'S 10TH-GENERATION CPU IN YOUR NEXT LAPTOP

We've just given five good reasons to wait for a 10th-generation CPU in your next laptop, but the 8th-generation family is hardly obsolete. Here are five reasons you could still buy a laptop with an 8th-gen CPU, with no regrets.

1. 10TH GEN IS FASTER, BUT NOT THAT MUCH FASTER

With their increased efficiency and smarter use of Turbo Boost, Intel's 8th-gen CPUs are pretty spectacular. The 10th-gen chips will

be faster, but probably not enough for most people to tell the difference. Its fancy new AI performance offers an advantage only in apps that can use it. The encoding will be much faster only if the software supports it. For the average user buying an ultrathin laptop to drive Office or a web browser, the difference between an 8th-gen laptop and 10th-gen laptop will mostly be incremental. It's not the quantum leap we saw with the change from 7th gen to 8th gen, where you doubled the amount of CPU cores.

2. GAMING IS BETTER, BUT IT'S NOT A GAMING LAPTOP

Graphics performance on the new 10th-gen cores are indeed a big step forward for integrated graphics. Adaptive Sync support also helps by smoothing out less-than-ideal frame rates.

Unfortunately, these big improvements don't mean 10th-gen laptops can suddenly game. Far from it. In fact, if you look again at the "1080p Gaming" chart above, the performance will probably be far worse with newer games. We're not being haters but if you want to play games on a thin, light, 10th-gen machine, learn how to use an external GPU with a laptop (go.pcworld.com/xtgc) for far better results.

3. 10TH-GEN LAPTOPS WILL BE PRICIER

If you're driven by a deal more than sheer performance, 8th-gen laptops are the better choice at the moment. In the early days, sparse availability will keep 10th-gen prices high. The new LPDDR4X RAM will also add to the cost. When 10th-gen laptops finally roll out in large volumes, you'll see 8th-gen laptops offering discounts and other incentives.

4. 10TH-GEN LAPTOPS WILL BE HARD TO GET

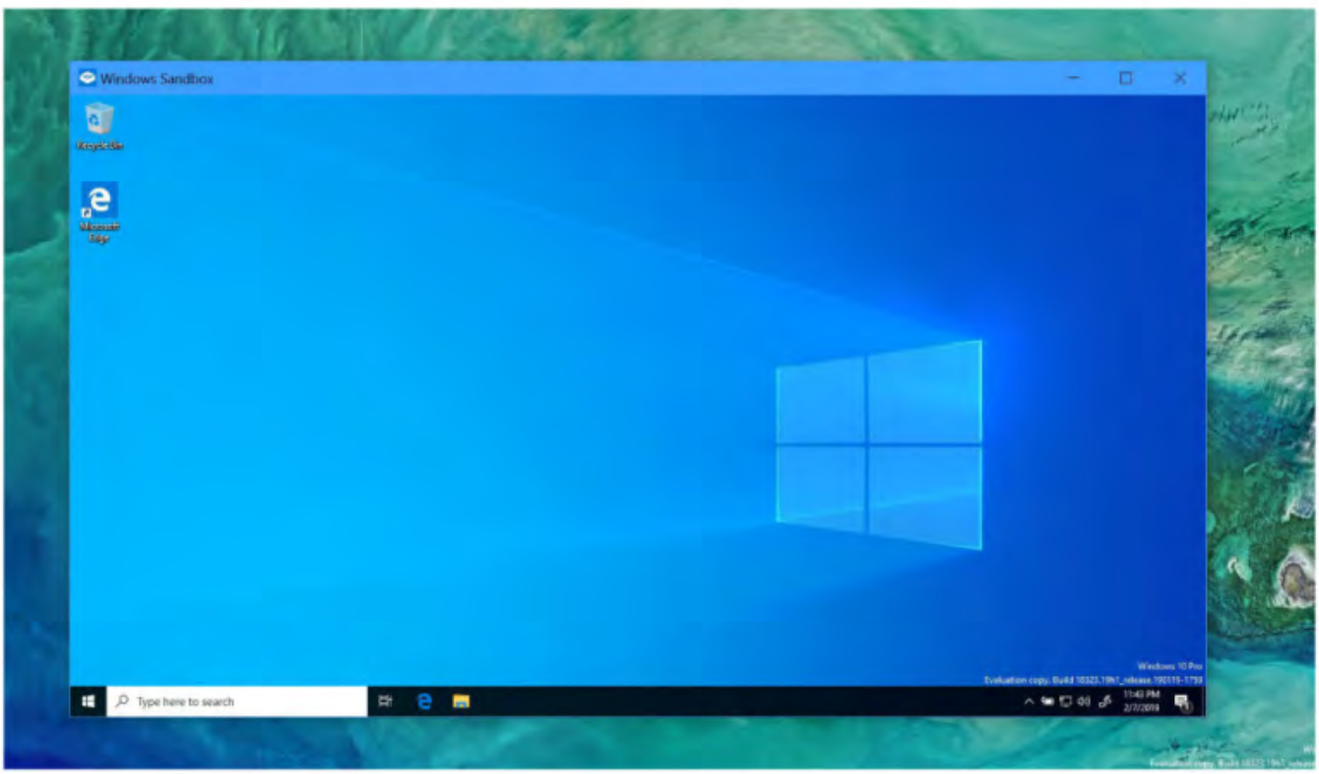
There are two kinds of CPU launches: The kind where the new CPU seems to replace the previous model overnight, and the kind where both live alongside each other in harmony for so long, you're confused as to which one to buy. Like this time. If you have to buy a laptop today for work or school, it'll be far easier and more affordable to get a good 8th-gen laptop.

5. 8TH-GEN WHISKEY LAKE LAPTOPS ARE REALLY, REALLY GOOD

Intel's 10th-gen CPUs bring a lot of new advantages, but the current 8th-gen "Whiskey Lake" laptops are really, really good. They're so good that the move to 10th-gen is going to be incremental for most people. Unless you must always have the newest hardware, or you really live on the edge of performance, buying from today's 8th-gen Whiskey Lake CPUs is not a mistake.

Windows Sandbox: How to use Microsoft's virtual Windows PC to secure your digital life

Protect your PC from harm when you try out suspicious software. **BY MARK HACHMAN**



Microsoft may have positioned its easy-peasy Windows Sandbox within the Windows 10 May 2019 (go.pcworld.com/10my) Update as a safe zone for testing untrusted applications, but it's much more than that. Windows Sandbox, and sandboxing PC apps in general, give you a solution for trying a "utility" that may be malware, or a website that you're not sure about. You could leave those potentially dangerous elements alone, but with Sandbox, you can be a little more adventurous.

Windows Sandbox creates a secure

IMAGE: MARK HACHMAN

"Windows within Windows" virtual machine environment entirely from scratch, and walls it off from your "real" PC. You can open a browser and surf securely, download apps, even visit websites that you probably shouldn't. Sandbox also includes a unique convenience: it lets you copy files in and out of the virtual PC, bringing them out of quarantine if you're sure they're safe.

At any time, you can close Windows Sandbox, and when you do, anything left there is totally obliterated. If that dodgy website rains malware down on your Sandbox, all it takes is one click to shut it down, without harm to your actual Windows installation. Next time you launch a new version of Sandbox, it will launch a pristine version of Windows 10 to start anew.

You won't need to buy a second copy of Windows to use the Windows Sandbox feature either—though you will need Windows 10 Pro or Enterprise. The Home version doesn't support it.

Here's everything you need to know to start using Windows Sandbox.

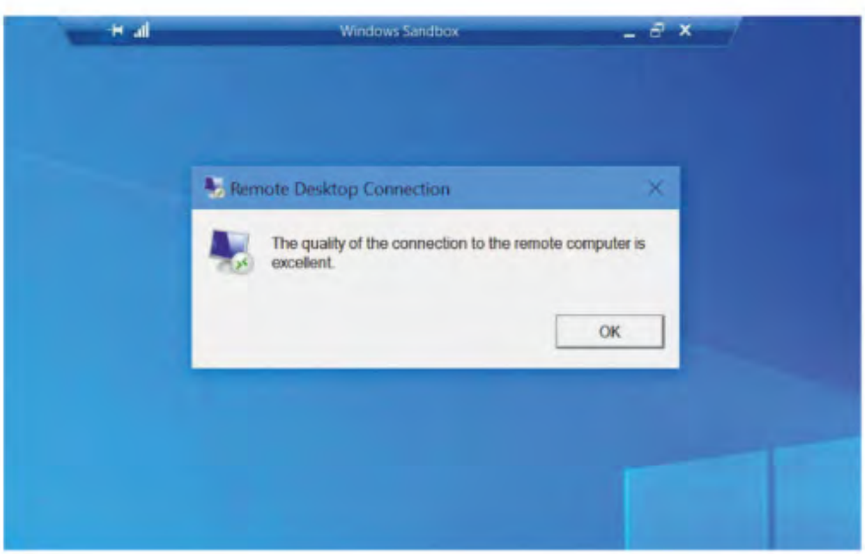
GET STARTED WITH WINDOWS SANDBOX

Windows Sandbox, in a window, looks like Windows—because it is. It's just another Windows desktop firewalled from your primary installation.

Technically, Windows Sandbox is a lightweight virtual machine, a tool often used by developers and researchers to test new software within a controlled environment. Virtualization creates an entire virtual computer, complete with operating system, storage, and memory, within your existing Windows PC.

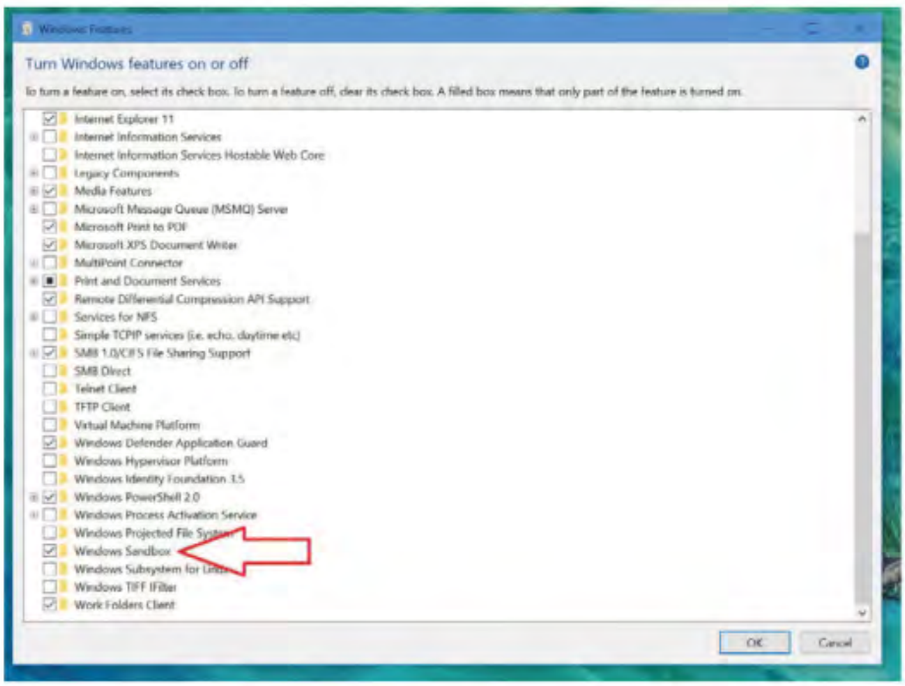
Granted, Windows already offers Hyper-V to achieve similar tasks. What makes Sandbox so appealing is that Sandbox is to Hyper-V as Windows 10's Mail app is to Outlook: a simplified, user-friendly version of a much more complex application.

Beyond the Windows 10 Pro requirement, Windows Sandbox's performance impact



If you open Windows Sandbox as a full-screen window, you'll see some additional icons. Clicking the cellular-style signal bar produces this message, in part because the "remote" Windows you're connecting to isn't remote at all.

demands a modern, fairly powerful machine with virtualization capabilities. Here are the minimum specifications for the feature:



To enable Windows Sandbox, you'll first need to install it.

- A 64-bit processor capable of virtualization, with at least two CPU cores; Microsoft recommends a quad-core chip. (Virtually all Intel processors sold since 2016 support virtualization, though this Intel guide (go.pcworld.com/vtlz) explains how to check. Otherwise, the Performance tab within the Task Manager will tell you whether virtualization is enabled—credit to Shailesh Jha (go.pcworld.com/sjah) for the reminder.
- Virtualization enabled in your motherboard BIOS, if it's not already
- Windows Pro, Enterprise, or Server
- At least 4GB of RAM (8GB is recommended)
- At least 1GB of free disk space (SSD recommended)

Windows Sandbox is an alternate feature of Windows, and it won't be installed by default even if it's available to you. To enable it, you'll need to go to the Windows Features control panel, which you can find by searching for Turn Windows Features On And Off. To enable Sandbox, you'll need to scroll down and check the proper box. Windows will install the necessary files and may need to reboot your PC.

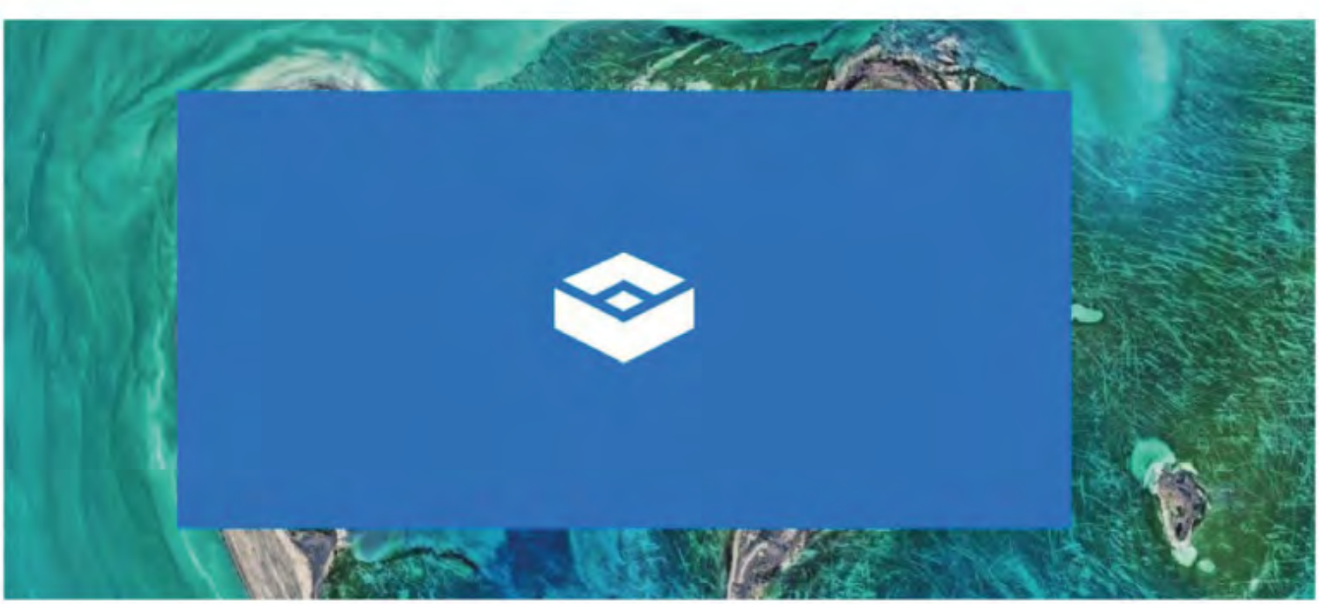
When the installation process is completed, there won't be any bells or whistles. To enable Sandbox, you can simply type Windows Sandbox into the Windows search box. It may take a minute or two to load, if only because Windows needs to establish the virtual machine. Microsoft has said previously that it will "freeze" the state of the virtual machine, archive it, and bring it up when you launch Windows Sandbox again—basically, everything should launch faster next time around.

HOW TO USE WINDOWS SANDBOX

Sandbox appears as a small window on your desktop. Within it, there's another Windows desktop, like what you might see if you installed Windows 10 and decided to use a local account.

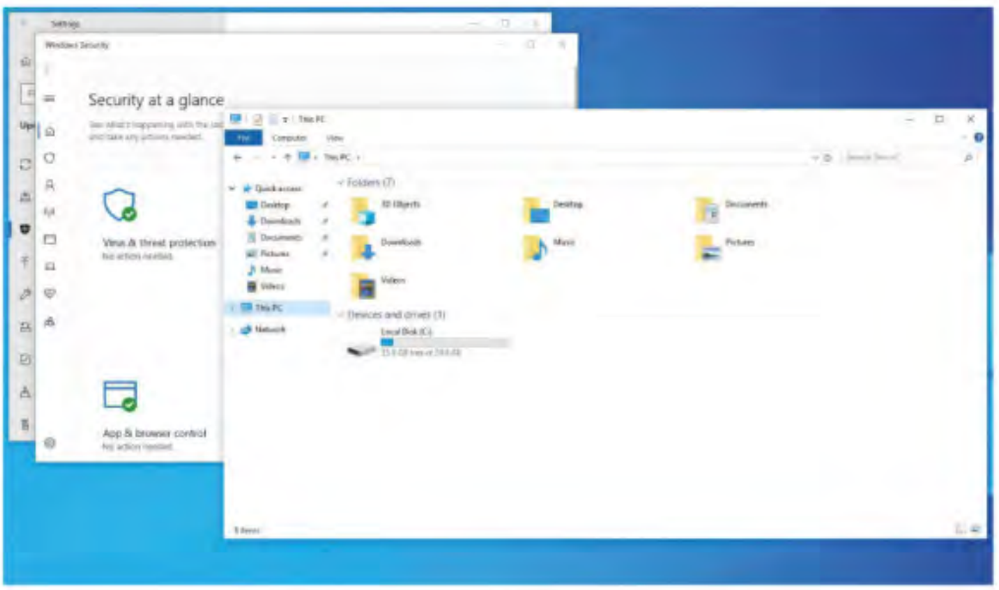
The Sandbox virtual PC isn't quite like your own. For one thing, none of the personalization options you've installed (go.pcworld.com/prsn) will carry over, such as favorites and themes. And that's good! One of the ideas behind Sandbox is not to put your personal information out into the wild, so don't be tempted to log in with your personal account. None of your third-party software will appear either. You still have access to File Explorer, but it's restricted to the Sandbox, with a subset of your PC's resources available. Note, too, that only one instance of Windows Sandbox is allowed at a time.

You'll probably be immediately tempted to open Windows Sandbox as a full-screen app. That's fine, especially as Microsoft has helpfully placed a large, Windows XP-style header at the top of the window, reminding you that you're working within Sandbox. Pay attention to it—the last thing you want to do is carelessly switch back to your "real" PC and open that dodgy website that you meant to launch in Sandbox. Edge browser and File Explorer windows opened within Sandbox won't identify themselves as the Sandbox versions. Feel free to play around with the Windows Settings within Sandbox, if you'd like, and see how it differs from your main Windows installation.



The Windows Sandbox splash screen. You'll see this for several seconds each time you launch Sandbox. An empty Sandbox window consumed about 1.2GB of memory in our tests running on a first-generation Surface Laptop, so you may be able to leave a Sandbox window open.

Because Windows Sandbox isn't run as a virtual machine, but as an app, there's not as much of a performance hit on your PC as a true virtual machine. (If you'd like to know more about the technical underpinnings of Sandbox, check out Microsoft's support page (go.pcworld.com/undr). But be aware that Sandbox is going to take a chunk of your PC's resources for its own use, including a portion of the CPU, memory, and disk space. If your PC is already pokey, both it and the Sandbox virtual PC will run even more slowly.



This is how much storage Windows assigned to Windows Sandbox, with 132 GB free on our Surface Laptop test machine.

Sandbox's app status also benefits you if you ever want to interact with any files you may have downloaded. A Hyper-V virtual machine isolates the file system so that malware can't escape. Any files you want to copy out of a Hyper-V VM requires a Remote Desktop connection or Enhanced Session Mode. Normal people don't want to deal with any of that! Sandbox simply allows you to cut and paste (or copy) any file on it right to your "real" desktop. That's very handy if the utility you were testing turns out to be useful after all.

I didn't notice any bugs or crashes associated with Sandbox, with one exception. If you're having trouble accessing the Internet from within Windows Sandbox, as I did, you may want to tweak your firewall settings to allow access to the Sandbox apps, or simply adjust your global protection settings.

Windows Sandbox won't tell you if a dodgy program is secretly sending information back to a third-party server, or whether some other pernicious activity is taking place without your knowledge. (Advanced users could monitor network traffic if they desired, however.) But if that file a "friend" sent you turns out to be ransomware, it won't do any harm in Sandbox.

Remember, you can close down Windows Sandbox at any time. When you do, you'll receive a message that whatever is stored within it is gone for good. The protections Sandbox offers go away if you copy a hazardous file from within the virtual machine out to your main Windows installation, of course.

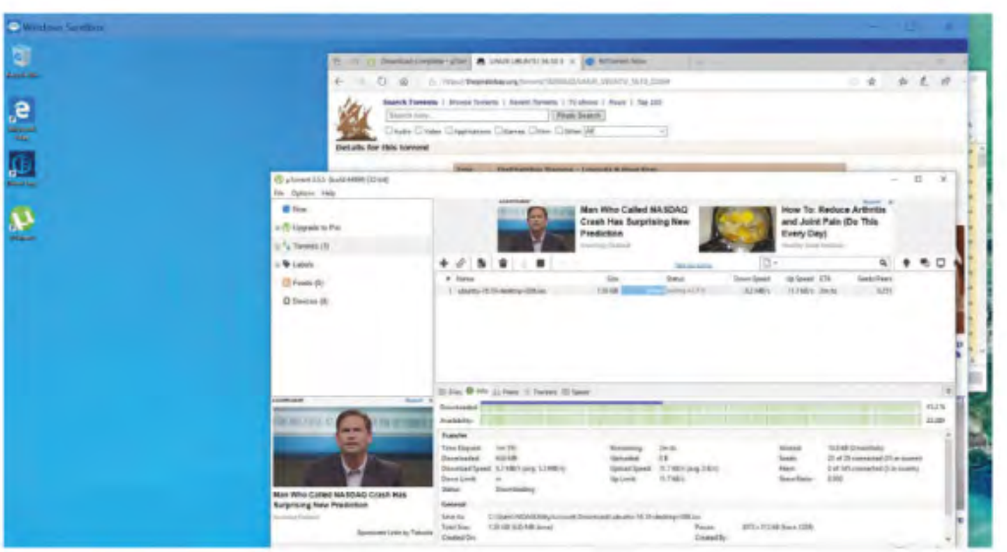
ADAPTING WINDOWS SANDBOX FOR EVERYDAY USE

What you may quickly realize, however, is that Sandbox is more than just a testbed for apps you're not sure about. It's also a bonus layer of security when you're poking about the web. We liked Windows 10's hidden secure browser, Windows Device Application Guard (go.pcworld.com/wndg), but it allowed you to download files only to its own secure environment. With Sandbox, you can copy files between Sandbox to your PC.

Both Microsoft Edge and Google Chrome include their own sandboxing elements to protect your PC. But if you really don't trust a particular site, you can always open Edge within your Sandbox (creating a sort of "sandbox within a Sandbox") and open that untrusted site. Are you a bit skeptical that Chrome's Incognito mode doesn't track your browsing? Download Chrome within Sandbox, surf away without logging into your Google account, then destroy your whole session by closing Sandbox.

Windows Sandbox doesn't anonymize your viewing—your Internet provider will still theoretically have a record of what sites you've visited, unless you also use a VPN—but when you destroy the Sandbox, that browsing record totally disappears. And if you download something you're not sure about, you can always test it within Sandbox to help determine whether it's actually malicious.

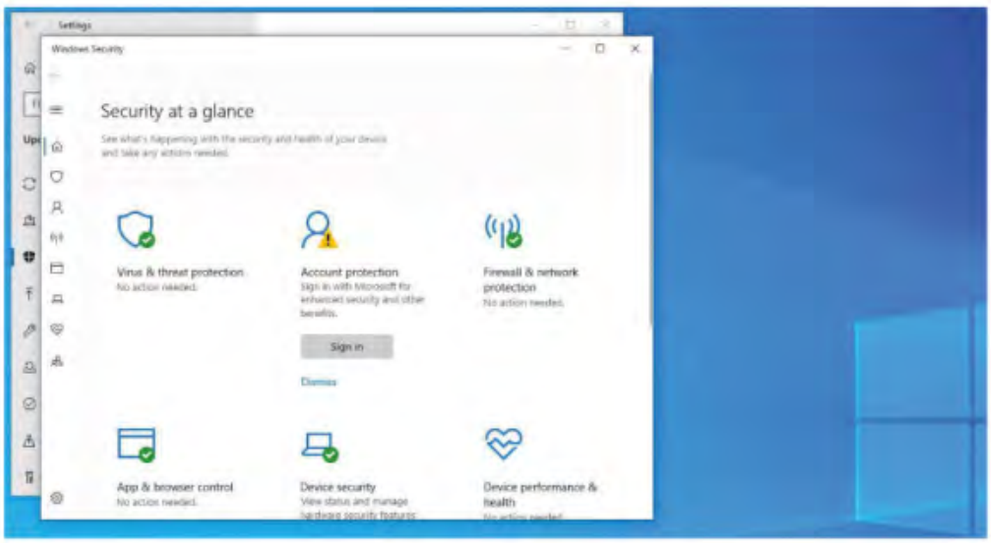
Oddly, Windows Defender doesn't seem



BitTorrent worked just fine. You never know what exactly you're downloading, though, which is why Sandbox might be a good idea.

to work within Sandbox, but I downloaded a free third-party antivirus from BitDefender and was able to check individual files for malware.

As we noted earlier, Sandbox demands a price in terms of performance. Running on a first-gen Surface Laptop (with a Core i5-7200U Kaby Lake chip powering it), just three media-rich Edge tabs within Sandbox gobbled up enough resources to keep the total CPU utilization well above 90 percent. I occasionally saw a bit of stuttering when moving down a webpage. With a more robust Surface Pro (2017; go.pcworld.com/micr) and a few code revisions later, Windows Sandbox ran much more smoothly.

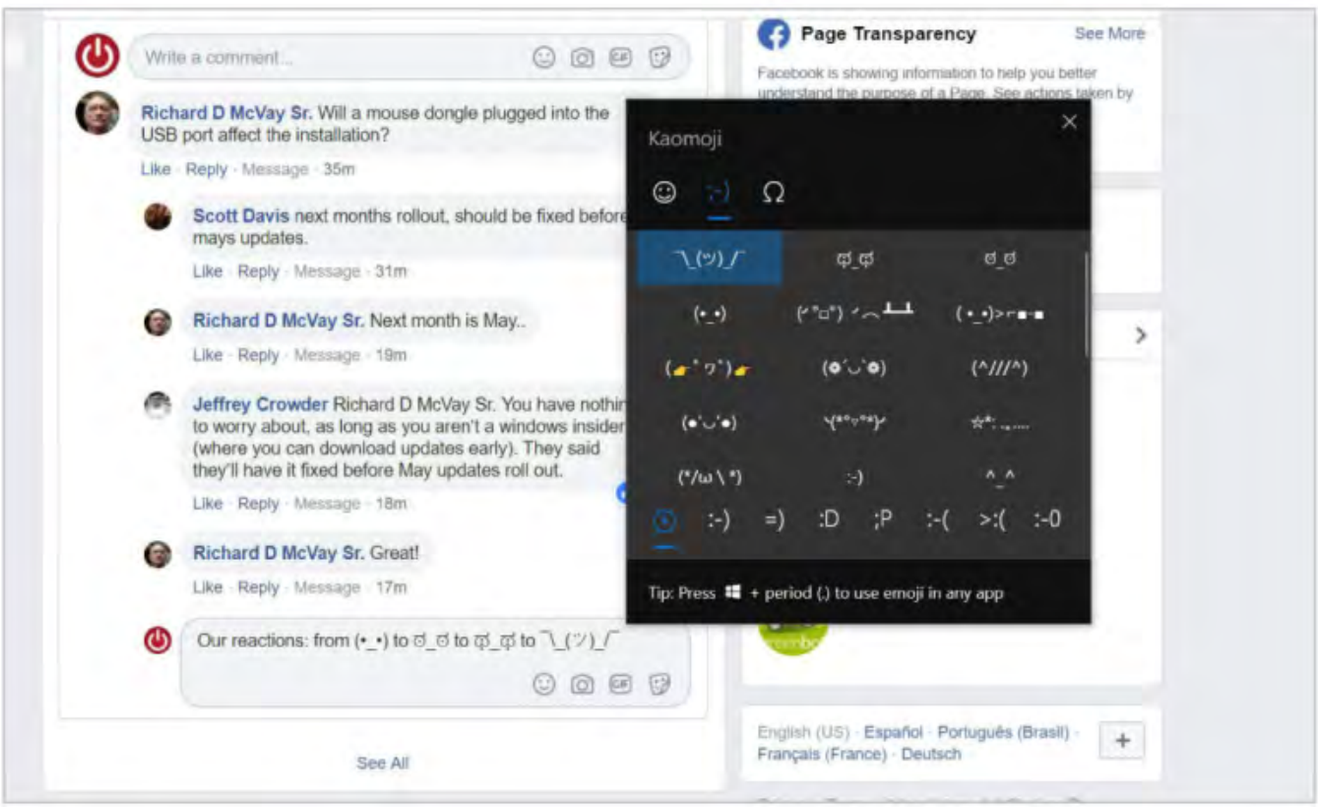


You won't see any personalization options by default. It's probably a good idea to leave your personal data out of Sandbox unless necessary.

Don't think that you'll be playing games within Sandbox. But opening an email via Outlook.com? Sure. Downloading what I thought was a Linux distribution over uTorrent? That worked just fine. (Trying to mount the ISO file within Sandbox, though, did not.)

How far you incorporate Sandbox into your everyday life is up to you. We've already seen Sandbox videos demonstrating the effects of computer viruses (go.pcworld.com/vrus)—because when they've finished wreaking havoc on the Sandbox virtual machine, the Sandbox can be shut down. (We still wouldn't recommend this with known dangers, as we can't say for certain that malware won't be able to break out of the Sandbox virtual machine.) Nevertheless, Sandbox offers the potential for much more than app trials.

Note that there are other third-party sandbox applications that you can still try: Sandboxie (both free and paid versions); BitBox, designed specifically for browsing; ShadeSandbox, and more. All of them have their own pros and cons. What Windows Sandbox offers, though, is the convenience of a free, secure sandboxing solution built right into Windows. And soon, everyone with Windows 10 Pro will have it.



How to type kaomoji on your PC in Windows 10

We'll show you how to type emoji, kaomoji, and symbols, in just a few easy steps. It's incredibly easy with Windows 10. **BY MARK HACHMAN**

How can I type kaomoji on my PC? And what are kaomoji, anyway? Fortunately, the answers to both questions are simple, and easily accessible within Windows 10's May 2019 Update. The familiar emoji keyboard (go.pcworld.com/emjk) within Windows has been expanded to include both kaomoji and symbols, and adding them to Facebook, Twitter, and other social media apps is extremely easy.

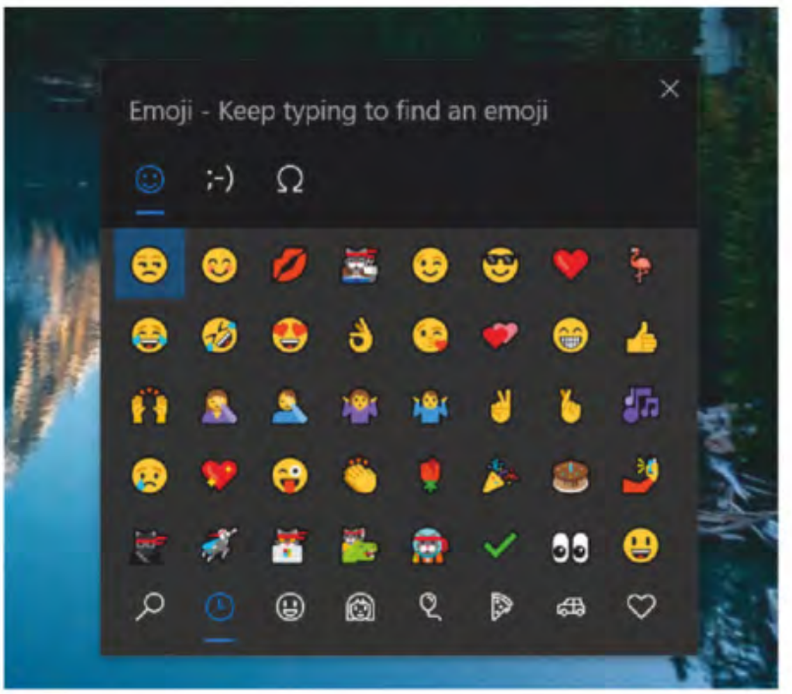
What's a kaomoji? A kaomoji is simply a more complex emoticon, the predecessor to the emoji. You're probably familiar with the smiley :) or winky ;) which consist of familiar punctuation symbols combined to form an expression. That's an emoticon. Emoji are simply pictorial representations of emoticons, so that a winky symbol is represented as a 😉.

IMAGE: MARK HACHMAN

A kaomoji, meanwhile, is to an emoticon like a finished painting is to a rough sketch: a complex arrangement of symbols that approaches art. With a kaomoji, you can express a complex idea that an emoji or emoticon simply can't: flipping a table in anger (ノ ゜ □ ゜)ノ ‿ ┻━┻, a double finger-pistol gesture (☞ ゜ ヮ ゜)☞, or even the obscure meme where CSI Miami's David Caruso takes off (or puts on) his sunglasses before saying something profound (• _ •)> ⌐■-■.

How do you access emoji, or kaomoji, or symbols within Windows 10? You can do it all with the same Windows shortcut: the WIN + ; shortcut (or WIN + .), where you hold down the Windows key, then type a semicolon. You can even access the new Emoji 12 emoji, which include representations of things like diving masks and flamingos, from the same keyboard. Alternatively, you can right-click a text box, and you should see an emoji option pop-up.

There's just one catch: You'll need the Windows 10 May 2019 Update (go.pcworld.com/10ma) to access the new kaomoji, also



The first option that the emoji keyboard reveals, is, unsurprisingly, emoji. You can either click what you're looking for, type in a search request at the top, or move to the kaomoji or symbols tab. Notice the nav bar at the bottom to move between categories.

Here's what the kaomoji keyboard looks like. Note there's a bit more explanation of how Windows organizes kaomoji as part of the nav bar at the bottom.

known as version 1903. If you're having trouble accessing these new emoji and kaomoji, type **winver** into the Windows search bar, then make sure the second line says Version 1903. The May 2019 Update started rolling out May 21, and users will receive the upgrade in waves. (If you want the May 2019 update right away, here's how to get it (go.pcworld.com/gtmy).)

HOW TO TYPE KAOMOJI UNDER WINDOWS 10

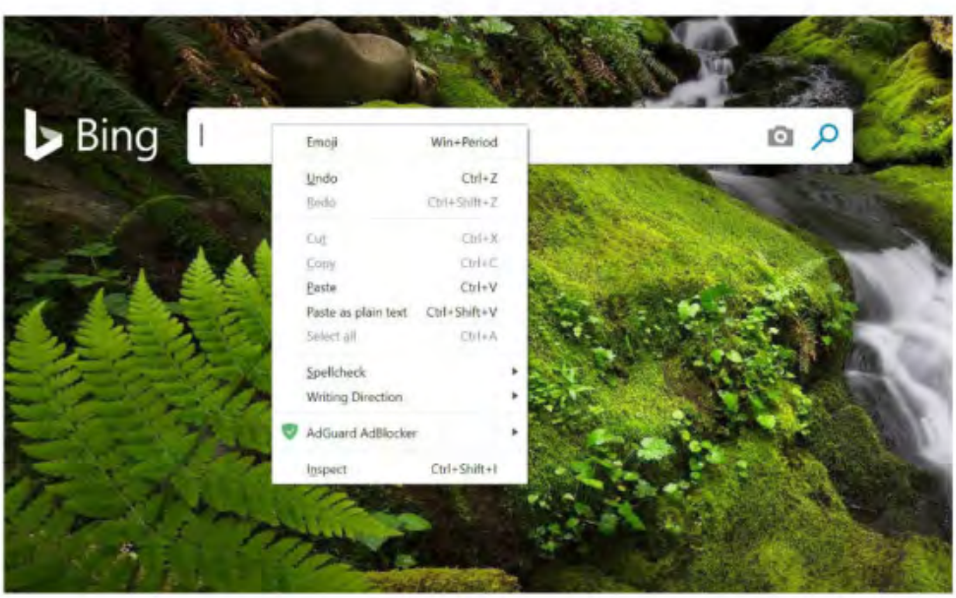
There are some subtleties to typing kaomoji under Windows 10, however. For one thing, they're confusingly organized.

The emoji keyboard contains three tabs: emoji, kaomoji, and, lastly, symbols of all types. The emoji tab is well organized, with a search function at the very top: type in **lips**, for example, and the "kiss" and "mouth" emoji will appear. For each emoji you'll also receive some explanatory text describing each one.

Tab over to the kaomoji keyboard, and there's nothing like that—yet. Hopefully you'll have a rudimentary knowledge of what symbol means what, or that they're detailed enough to figure out on your own. Yes, there's a nav bar of sorts on the bottom, a "I didn't even see that" way to navigate between happy, sad, silly, and other kaomoji—but the nav bar itself is also done in emoji, which seems a little much. Pop-up text provides some rudimentary explanation. This is a largely self-guided tour.

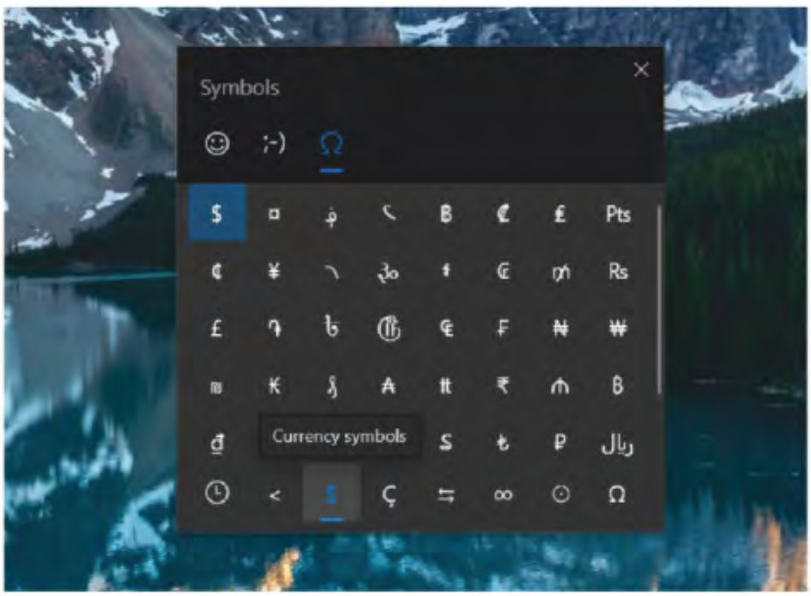
(That same odd, bottom-row nav bar applies to the symbols menu, too. At least there's some explanatory text when you hover your cursor over the navigation bar, with categories that include "general punctuation," "currency symbols," "Latin symbols," and more.)

Remember that emoji are single symbols, so that you won't have to worry about line breaks. Kaomoji and emoticons are not so



Oddly enough, the right-click emoji keyboard option does not appear in Word, or even Notepad. But if you want to search Bing for emoji, you have Microsoft's blessing.

lucky, and a long, complex cluster of symbols may end up broken over two lines by an app. You'll need to plan accordingly. Fortunately, whether they be emoji or kaomoji or ordinary symbols, they're all supported by Microsoft apps like Word, Edge, and even Notepad, so you should be able to type them within any app you choose. Just make sure you have the window or app in focus or active, open the emoji keyboard, and type away. While an early implementation of the emoji keyboard allowed only one character per instance of the keyboard, that's a bug that's been fixed. Type as many as you want!



Microsoft's symbols keyboard, part of the emoji keyboard within Windows 10, also has a large variety from which to choose.

Because you'll be using this keyboard to type emoji as well as kaomoji, there's one change worth noting: the location of the "swatch" drop-down menu, a key feature in the emoji keyboard we introduced you to two years ago (go.pcworld.com/emjk). Instead of putting it under the "most recently used" tab of the emoji keyboard—the one you'll see first every time you open it—Microsoft has moved it to the fourth emoji tab on the bottom. (It's there in the third tab if you're viewing this on something earlier than the May 2019 Update.) Regardless, if you hover over it, you'll see it labeled as People. Only emoji have various color options.

Microsoft could benefit from some improvement in the overall emoji keyboard experience: for example, a clearer signal, via color or delineation, that a search box is actually present. Asking someone familiar with kaomoji to add some brief explanatory text that would display while your cursor hovered over it would provide a gentler entrance for those who have never used them before. A resizable window? Yes, please. You can't type kaomoji, then text, then another kaomoji while the keyboard remains open. And Microsoft really needs to fix the bug that causes the emoji keyboard to move slooooowly across your screen when you reposition it.

Otherwise, though, it couldn't be simpler: the WIN + ; opens the door to a new way of expressing yourself. Welcome to kaomoji!. ╰(*° ▽° *)╯

Tech Spotlight

A video showcase of the latest trends

Project Athena laptops

After unveiling its "Project Athena" vision for the future of mobile computing at CES in January, Intel finally provided more detail on what exactly will be inside certified laptops that will begin shipping later this year. Our Mark Hachman saw numerous examples at Computex in Taipei.