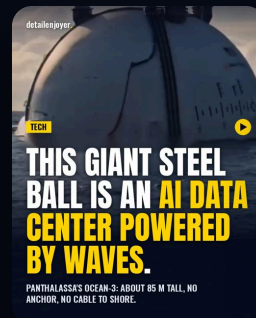




COLLECTION · COL-08

FROM TRANSISTORS TO QUBITS

The hardware behind computing, from Ada Lovelace's notes and 1971 to a film made of molecules and the quantum fridge.



INSIDE

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DID YOU KNOW?

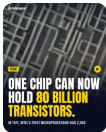
11 case files · 22 quiz questions · by DetailEnjoyer

ABOUT THIS COLLECTION

11 case files on the hardware behind computing, from Ada Lovelace's program notes and a 1971 microprocessor and a film made by moving single molecules to quantum chips and the data centers that run them. Intel's first microprocessor, the 4004 (1971), had 2,300 transistors. NVIDIA's GH100 chip has 80 billion on one 814 mm² die. **DD-018** A superconducting quantum chip sits on the bottom plate of a dilution refrigerator at around 10–15 millikelvin, more than 180 times colder than deep space. **DD-012**

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Shrinking Circuits

DD-018 · Tech · One chip can now hold 80 billion transistors.

02



TeraFab

DD-016 · Tech · Musk's planned chip plant would cover 100 million square feet.

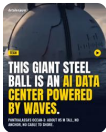
03



Quantum Infrastructure

DD-012 · Science / Tech · This golden chandelier keeps qubits colder than outer space.

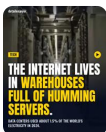
04



Ocean-3

DD-022 · Tech · This giant steel ball is an AI data center powered by waves.

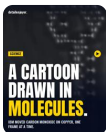
05



Data Centers

DD-029 · Tech · The internet lives in warehouses full of humming servers.

06



Atomic Stop-motion

DD-663 · Science / Tech / Media · A cartoon drawn in molecules.

07



Ada All-Time

DD-095 · People / Tech · A program was written for a computer that was never built.

08



The Future Is Now

DD-238 · Tech / Science · Every chip starts as a thin slice of silicon called a wafer.

09



Entanglement

DD-080 · Science · Entangled particles stay correlated however far apart they are.

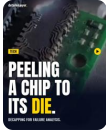
10



Quantum Shenanigans

DD-338 · Science · One equation tells how a quantum system changes over time.

11



A Look Inside

DD-389 · Tech / Science · Decapping strips a chip's package to expose the silicon die.



Collection Quiz and Answer Key

22 questions from every case file

Every quick fact has a stable ID (for example DD-018-F01) and comes from a case file with its sources listed. Online edition with videos and slides: <https://detailenjoyer.com/collections/transistors-to-qubits/>



DD-018 TECH · 1 OF 11

SHRINKING CIRCUITS

The first integrated circuits (1958–60) had just one to four transistors. Intel's 4004 microprocessor (1971) had 2,300 on a 12 mm² die built with a 10-micrometer process. Today a single chip such as NVIDIA's GH100 packs 80 billion transistors onto 814 mm², thanks to decades of shrinking features. Even so, modern node names like '5 nm' are generation labels, not literal transistor sizes.

QUICK FACTS

DD-018-F01

Intel's first microprocessor, the 4004 (1971), had 2,300 transistors. NVIDIA's GH100 chip has 80 billion on one 814 mm² die.

DD-018-F02

Process names like '7 nm' are generation labels: a '7 nm' transistor's gate is actually about 15 nm long.

THE WRITE-UP

It started with one transistor. Jack Kilby's 1958 'solid circuit' had a single transistor. Fairchild's first planar integrated circuit, in 1960, had four transistors and five resistors.

2,300 transistors in 1971. Intel's 4004, released November 15, 1971, was the first commercially available microprocessor: a whole 4-bit CPU on one chip with 2,300 transistors.

Ten micrometers. The 4004 was built on a 10 µm (micrometer) process on a die of about 12 mm². Its minimum line width was 10 microns.

From 10 µm to about 10 nm. Shrinking transistor features drove the growth in transistor count, from 10 µm in the early 1970s to around 10 nanometres by 2017: a thousandfold shrink.

Tens of billions today. NVIDIA's full GH100 die, which powers the H100, has 80 billion transistors on a single 814 mm² piece of silicon, made on TSMC's 4N process.

'3 nm' isn't 3 nm. Node names stopped matching physical sizes about two decades ago. Most critical features of a '7 nm' transistor are much larger than 7 nm; its gate is about 15 nm long, for example.

REEL VS. RECORD

- **Imprecise:** 'Early integrated circuits contained only a few thousand transistors.' The very first ICs had far fewer: Kilby's 1958 circuit had one transistor, and Fairchild's 1960 planar IC had four. 'A few thousand' fits early-1970s chips like the Intel 4004 (2,300). [CHM Silicon Engine; Smithsonian; CHM Revolution]
- **Unit slip:** 'a piece of silicon only a few hundred square millimeters across'. Square millimeters measure area, not width. Big modern dies are a few hundred mm² in area (GH100: 814 mm², about 28.5 mm on a side). [NVIDIA; Embedded.com]
- **Context:** 'nanometer-scale process generations' is fair, but today's node names (7 nm, 5 nm, 3 nm) are labels, not physical transistor dimensions. [IEEE Spectrum, x2]

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Permalink: <https://detailenjoyer.com/case/shrinking-circuits/> · Last updated Aug 16, 2026



DD-016 TECH · 2 OF 11

TERAFAB

TeraFab is the AI-chip complex that SpaceX and Tesla plan to build in Grimes County, Texas. It would make, package and test logic and memory chips under one roof. Texas announced the first phase on Aug 6, 2026: more than \$16.8 billion, 3,000 jobs and a 100-million-square-foot facility. Tax filings sketch four phases worth up to about \$119 billion, but the later phases aren't committed.

QUICK FACTS

DD-016-F01

Terafab, SpaceX and Tesla's planned chip complex in Grimes County, Texas, would span 100 million square feet, with a first phase of more than \$16.8 billion.

DD-016-F02

Terafab's tax filings sketch four phases worth up to about \$119 billion, but only the \$16.8 billion first phase has been announced.

THE WRITE-UP

A chip plant in Grimes County. On Aug 6, 2026, Texas Governor Greg Abbott announced that SpaceX will build Terafab, a vertically integrated semiconductor fabrication plant, in Grimes County, about 20 miles east of College Station, near Gibbons Creek Reservoir.

Everything under one roof. Terafab is meant to make, package and test advanced logic and memory chips in one place. In Musk's words, it combines 'logic, memory, and advanced packaging all under one roof'.

\$16.8 billion to start. The first phase is a capital investment of more than \$16.8 billion with 3,000 new jobs. The total is about \$10.37 billion in the Anderson-Shiro district plus \$6.43 billion in the Lola district. Texas added a \$30 million Texas Enterprise Fund grant.

100 million square feet. The planned facility covers 100 million square feet. The chips are meant for Tesla's Optimus robots and Cybercabs and for SpaceX's space-based data centers.

Up to \$119 billion, if every phase gets built. State tax-incentive filings describe four phases (2026–28, 2029–31, 2032–34, 2035–36) totalling about \$119.4 billion. The applicant says it will decide on each later phase only after finishing the one before.

Who's behind it. The filings were made by TeraFab AI, LLC, a SpaceX-linked entity. ENR describes the project as led by affiliated companies including SpaceX, Tesla and xAI.

Timeline. First-phase construction is projected for 2026–28, with commercial operations expected to begin in 2028.

REEL VS. RECORD

- **Nuance:** '\$119 billion' is a potential total across four phases in tax-incentive filings, not committed spending. SpaceX says it will decide on phases 2–4 only after each earlier phase is finished. [ENR source guide; KBTX; ENR]
- **Nuance:** the governor's announcement names SpaceX. Reuters reports SpaceX and Tesla, and the filings come from SpaceX-linked TeraFab AI, LLC, with ENR naming SpaceX, Tesla and xAI. 'SpaceX and Tesla's' is fair shorthand. [Texas Governor; Reuters; KBTX; ENR]
- **Confirmed:** Grimes County, vertical integration (logic, memory, packaging, testing), the \$16.8B first phase and 100 million sq ft. 'More than \$16.8 billion' is the official wording. [Texas Governor; Reuters]

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Permalink: <https://detailenjoyer.com/case/terafab/> · Last updated Aug 9, 2026



QUANTUM INFRASTRUCTURE

The gold 'chandelier' in photos of quantum computers is really a refrigerator. Superconducting qubits are so easily disturbed that the chip sits on the bottom plate of a dilution refrigerator. Each stage of the fridge is colder than the one above, and the bottom plate is held around 10–15 millikelvin by a mixture of helium-3 and helium-4. That is more than 180 times colder than the 2.7 K of deep space.

QUICK FACTS

DD-012-F01

A superconducting quantum chip sits on the bottom plate of a dilution refrigerator at around 10–15 millikelvin, more than 180 times colder than deep space.

DD-012-F02

Dilution refrigerators cool by pumping helium-3 across the boundary between two phases of a helium-3/helium-4 mixture, which only separates below about 0.87 K.

THE WRITE-UP

Fragile by design. Qubits must be almost perfectly isolated from heat, vibration and stray disturbances. Even then, they hold their quantum states for at most a few hundred microseconds before they 'decohere'.

The 'chandelier' is a fridge. The tiered gold structure is a dilution refrigerator. It has a stack of metal plates, each colder than the one above, with the top plate at room temperature.

Chip at the bottom. The quantum processor is mounted on the lowest and coldest plate, the mixing chamber. It sits inside a shielded package that blocks stray radiation and magnetic fields.

Helium-3 meets helium-4. Below about 0.87 K, a mixture of helium-3 and helium-4 separates into two phases. Pumping helium-3 across the boundary between them absorbs heat, like evaporation, and this provides continuous cooling.

About 10–15 thousandths of a degree. Commercial dilution refrigerators reach a base temperature of around 10 mK. IBM's fridges hold chips at about 10–15 mK.

Colder than deep space. Space is bathed in the 2.7 K cosmic microwave background. IBM says its fridges, at below 15 mK, are more than 180 times colder than deep space.

Getting bigger. In August 2026, IBM joined two cryogenic modules, each over 8 feet tall and wide, into one ultra-cold environment. The modules are designed to link hundreds of quantum chips.

REEL VS. RECORD

- **Confirmed:** the cryogenic stack protects qubits from heat, vibration and electromagnetic interference; the processor is mounted at the bottom; and the fridge cools with a He-3/He-4 mixture. [Bluefors; Oxford; PRX Quantum; Popular Science; MIT Tech Review]
- **Range check:** '10–20 mK' is fair. Base temperatures are typically ≤ 10 mK, with qubits operated around 10–15 mK. 'Colder than outer space' is correct (deep space is about 2.7 K). [PRX Quantum; Popular Science; IBM]
- **Nuance:** this applies to superconducting qubits, as the Reel says. Other kinds of quantum computers, such as trapped-ion and photonic, don't need a dilution refrigerator for the qubits themselves.

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Permalink: <https://detailenjoyer.com/case/quantum-cryogenics/> · Last updated Jun 13, 2026



DD-022 TECH · 4 OF 11

OCEAN-3

Ocean-3 is Panthalassa's series of wave-powered, floating AI computing nodes. Each one is an 85 m plate-steel structure shaped like a golf ball on a tee. As it bobs, seawater is driven up an internal tube to spin a turbine, which powers onboard GPUs. The nodes have no anchor and no power cable. They steer themselves, and they send results to shore by satellite. Pilot units were planned for the northern Pacific in 2026, with commercial deployments targeted for 2027.

QUICK FACTS

DD-022-F01

Panthalassa's Ocean-3 nodes are 85 m steel floating data centers that make their own power from waves and send AI results to shore by satellite.

DD-022-F02

Ocean-3 nodes have no anchor and no shore cable. They are self-propelled, and their CEO compares them to a giant Roomba.

THE WRITE-UP

A data center that floats. Ocean-3 is Panthalassa's series of autonomous nodes. They are designed to run AI inference computing at sea, powered by electricity they make from ocean waves.

About 85 meters of steel. Each node is about 85 m tall and made of plate steel, close to the height of Big Ben. New Scientist describes it as shaped like 'a golf ball sitting on a tee'.

How the waves make power. The 'tee' is a long tube open at the bottom. As waves lift and drop the node, seawater is pushed up the tube into the hollow, air-filled sphere, where it spins turbines. That electricity runs the onboard GPUs and satellite equipment.

No anchor, no cable. The nodes are self-propelled and aren't tethered to the seabed or connected to shore by a cable. They get towed out and then propel themselves to their station. CEO Garth Sheldon-Coulson calls it 'like a little Roomba, except it's enormous'.

Answers by satellite. Instead of sending power to shore, each node computes on board and sends its results (inference tokens) to customers by satellite link.

\$140 million from Thiel and others. On May 4, 2026, Panthalassa announced a \$140 million Series B led by Peter Thiel. The money will finish a pilot factory near Portland, Oregon, and speed up Ocean-3 deployment.

Prototypes first, pilots next. Earlier prototypes (Ocean-1 in 2021, then Ocean-2 and Wavehopper in 2024) proved power generation, propulsion and computing at sea. The Ocean-3 pilot series was planned for the northern Pacific in 2026, with commercial deployments targeted for 2027.

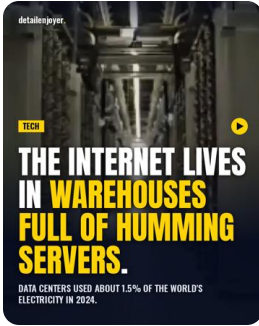
REEL VS. RECORD

- **Timing caveat:** the Reel describes Ocean-3 as if it's already running. In reporting through Aug 2026, the Ocean-3 pilots were still planned for the northern Pacific in 2026, with commercial deployments targeted for 2027. I couldn't confirm that a node has processed AI workloads offshore yet. [Panthalassa press release; Ars Technica; Fast Company]
- **Minor:** '85-meter-tall' matches most outlets. Ars Technica (citing the FT) says 'about 85 meters in length'. It's the same figure for the vertical node. [Ars Technica; New Scientist; Latitude Media]
- **Minor:** sources describe 'an internal turbine' (DCD, Latitude) or 'turbines' (New Scientist). The Reel's 'across turbines' is fine.

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DD-029 TECH · 5 OF 11

DATA CENTERS

Data centers are the buildings where the internet physically lives: racks of servers, storage and network gear, plus the power and cooling plant that keeps them running around the clock. In 2024 they used about 415 TWh of electricity, roughly 1.5% of the world's total, according to the IEA. In the U.S. they used 4.4% in 2023, and that share could reach 6.7–12% by 2028, according to Lawrence Berkeley National Laboratory. AI is the main driver of the growth, and the hottest AI chips now draw more than 1,000 W each, which is pushing operators toward liquid cooling.

QUICK FACTS

DD-029-F01

Data centers used about 415 TWh of electricity in 2024, roughly 1.5% of the world's total, and the IEA expects that to more than double by 2030.

DD-029-F02

Top AI chips now draw more than 1,000 watts each, which is why new data centers are switching to liquid cooling.

THE WRITE-UP

What's inside. A data center houses three kinds of IT equipment: servers, storage and networking gear. It also has the cooling and electrical infrastructure that keeps them running. Berkeley Lab's national estimate models all of these together.

1.5% of the world's electricity. The IEA estimates data centers used about 415 TWh in 2024, around 1.5% of global electricity. The U.S. accounted for 45% of that, China 25% and Europe 15%.

The U.S. picture. U.S. data centers used 58 TWh in 2014 and 176 TWh in 2023, which is 4.4% of national electricity. Berkeley Lab projects 325–580 TWh by 2028, or 6.7–12% of U.S. electricity.

AI is the accelerator. The IEA expects global data-center demand to more than double to about 945 TWh by 2030, slightly more than Japan uses today, with AI as the biggest driver.

Built never to go dark. The Uptime Institute rates facilities in four tiers. Tier II adds redundant (N+1) generators, UPS batteries and cooling. Tier III can be maintained without shutting down. Tier IV keeps two fully independent systems so that any single failure is tolerated.

Why liquid cooling. Leading AI chips now draw more than 1,000 W each, too much for air alone. The IEA's efficiency program says liquid cooling is a prerequisite for high-density AI racks and can cut cooling energy by roughly 30–40%.

Power and water trade-offs. Renewables and natural gas are both growing to meet data-center demand. Cooling also involves trade-offs: evaporative towers use less electricity but consume water, while dry coolers save water but use more power.

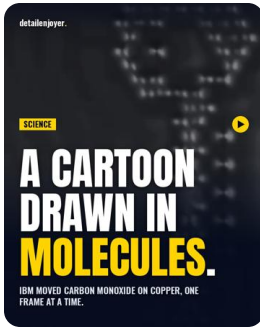
REEL VS. RECORD

- **Confirmed from the frames:** this is a general explainer about data centers, not a profile of one facility. Its footage is stitched from three accounts (ikassem85, i.linkstop and ccna_200_301). [frames]
- **Imprecise:** 'house thousands of servers'. Facilities range from small server rooms to hyperscale campuses, so 'thousands' undersells the largest and oversells the smallest. [LBNL 2024]
- **Nuance:** 'redundant power supplies, backup generators, battery systems ... so services remain online'. The level of redundancy varies by design tier. Tier I sites have no redundant capacity and must shut down for maintenance. [Uptime Institute; Uptime tier paper]
- **Incomplete:** 'renewable power integration'. The IEA says renewables and natural gas are both major sources for the new demand, so it isn't a renewables-only story. [IEA Energy and AI]
- **Confirmed and quantified:** AI is driving growth. Global data-center electricity is projected to rise from ~415 TWh (2024) to ~945 TWh (2030). [IEA Energy and AI; IEA executive summary]

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Permalink: <https://detailenjoyer.com/case/data-centers/> · Last updated May 16, 2026



ATOMIC STOP-MOTION

IBM Research released 'A Boy and His Atom' on April 30, 2013, and Guinness World Records certified it as the world's smallest stop-motion film. Scientists at IBM's Almaden lab in San Jose used a scanning tunneling microscope (STM) to drag carbon monoxide molecules across a copper surface, one frame at a time. The microscope ran at about -268°C (5 K), cold enough to hold the molecules in place, and magnified the surface more than 100 million times. Each CO molecule shows up as a dot. The team made 242 frames, each 45 by 25 nanometers, and Guinness says they did it between January 29 and February 6, 2013. Four researchers worked 18-hour days for about two weeks, using a few dozen molecules. Guinness describes the animation as 60 seconds long; the YouTube upload runs 1 minute 33 seconds with titles and credits. The film was outreach for IBM's atomic-scale data storage research, which in 2012 stored one bit of data in 12 atoms.

QUICK FACTS

DD-663-F01

Guinness certified 'A Boy and His Atom' as the smallest stop-motion film.

DD-663-F02

The film has 242 frames, each 45 by 25 nanometers.

THE WRITE-UP

The record. Guinness certified 'A Boy and His Atom' as the smallest stop-motion film in 2013. Each frame is 45 by 25 nanometers.

The tool. A scanning tunneling microscope moved carbon monoxide molecules on copper and imaged them, magnifying the surface more than 100 million times.

The cold. The microscope ran at about -268°C , which keeps the molecules where they're placed.

The frames. The team made 242 frames between January 29 and February 6, 2013, and IBM released the film on April 30.

Why IBM did it. It was outreach for atomic-scale storage research. In 2012, IBM stored one bit in just 12 atoms.

REEL VS. RECORD

- **Title:** the film is 'A Boy and His Atom' (the Reel writes '&').
- **Length:** Guinness gives the animation as 60 seconds. The 1:33 YouTube running time includes titles and credits.
- **Missing:** the molecules were moved by an STM at about -268°C (5 K). The cold keeps them in place.
- **Missing scale:** each frame is 45 by 25 nanometers, and the surface was magnified more than 100 million times.
- **Missing purpose:** IBM made it as outreach for atomic-scale data storage research, which in 2012 stored one bit in 12 atoms.

SOURCES

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2. Guinness World Records: Smallest stop-motion film: <https://guinnessworldrecords.com/world-records/smallest-stop-motion-film>
3. Wikipedia: A Boy and His Atom (citing BBC, AP and IBM): https://en.wikipedia.org/wiki/A_Boy_and_His_Atom
4. IBM Research (YouTube, Apr 30, 2013): A Boy and His Atom, the world's smallest movie: <https://www.youtube.com/watch?v=oSCX78-8-q0>

Permalink: <https://detailenjoyer.com/case/atomic-stop-motion/> · Last updated Oct 18, 2025



DD-095 PEOPLE / TECH · 7 OF 11

ADA ALL-TIME

Ada Lovelace (1815-1852) was an English mathematician who worked with Charles Babbage on his proposed Analytical Engine, a mechanical general-purpose computer. In 1843 she translated an article by Luigi Menabrea about the engine from French and added her own notes, which were longer than the article. Note G sets out an algorithm for computing Bernoulli numbers on the engine, often called the first published computer program. She also suggested the machine could act on things other than numbers, such as music. Historians debate how much credit belongs to her versus Babbage. The engine was never built. The footage shows portraits of Lovelace and Babbage, with the presenter.

QUICK FACTS

DD-095-F01

Lovelace published her notes in 1843.

DD-095-F02

Note G computes Bernoulli numbers.

THE WRITE-UP

Analytical Engine. Babbage's Analytical Engine was a proposed general-purpose computer.

1843 translation. Lovelace translated Menabrea's article and added her own notes.

Note G. Note G gives an algorithm for Bernoulli numbers.

Beyond numbers. She suggested the engine could act on symbols like music.

Never built. The Analytical Engine was never completed.

REEL VS. RECORD

- **Note:** 'First computer programmer': that's how she's widely described, but historians debate how much of the work was hers and how much was Babbage's. I kept the claim attributed.

SOURCES

1. Wikipedia: Ada Lovelace: https://en.wikipedia.org/wiki/Ada_Lovelace
2. Wikipedia: Note G: https://en.wikipedia.org/wiki/Note_G

Permalink: <https://detailenjoyer.com/case/ada-all-time/> · Last updated Nov 27, 2023



DD-238 TECH / SCIENCE · 8 OF 11

THE FUTURE IS NOW

Computer chips, or integrated circuits, are made on wafers of very pure silicon. Each wafer is coated with a light-sensitive photoresist and exposed to ultraviolet light through a mask in a step called photolithography, which prints the circuit pattern. Etching removes unwanted material, and the steps of deposition, doping, lithography and etching are repeated many times to build up billions of transistors. Finished wafers are tested and cut into individual dies, which are packaged into chips. The footage shows chip fabs and cleanrooms, with the presenter.

QUICK FACTS

DD-238-F01

Chips are built on silicon wafers.

DD-238-F02

Wafers are coated with photoresist.

THE WRITE-UP

Silicon wafers. Chips are built on silicon wafers.

Photoresist. Wafers are coated with photoresist.

Photolithography. Light through a mask prints the pattern.

Etching. Etching removes unwanted material.

Packaging. Dies are cut and packaged.

REEL VS. RECORD

- **Note:** The voiceover says 'silicone wafer'; chips are made on silicon, the element, not silicone.

SOURCES

1. Wikipedia: Semiconductor device fabrication: https://en.wikipedia.org/wiki/Semiconductor_device_fabrication
2. Wikipedia: Photolithography: <https://en.wikipedia.org/wiki/Photolithography>

Permalink: <https://detailenjoyer.com/case/the-future-is-now/> · Last updated May 22, 2024



DD-080 SCIENCE · 9 OF 11

ENTANGLEMENT

In quantum mechanics, entangled particles share a single quantum state, so measurements on them are correlated no matter how far apart they are. The correlations appear instantly, but they cannot be used to send information faster than light. Albert Einstein, who doubted the idea, called it 'spooky action at a distance.' Experiments have repeatedly confirmed entanglement, work recognized by the 2022 Nobel Prize in Physics.

QUICK FACTS

DD-080-F01

Entangled particles share a quantum state.

DD-080-F02

Measurements are correlated at any distance.

THE WRITE-UP

Shared state. Entangled particles share a quantum state.

Correlated. Measurements are correlated at any distance.

No signaling. It cannot send information faster than light.

Spooky. Einstein called it spooky action.

Nobel. Entanglement experiments won the 2022 Nobel.

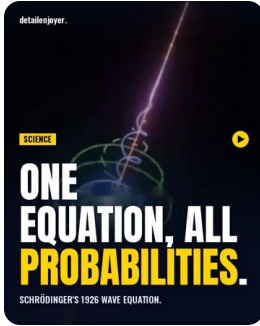
REEL VS. RECORD

- **Note:** The Reel says changing one particle instantly influences its partner; the measurement results are correlated, but no signal or information travels faster than light.

SOURCES

1. Wikipedia: Quantum entanglement: https://en.wikipedia.org/wiki/Quantum_entanglement
2. NobelPrize.org: The Nobel Prize in Physics 2022: <https://www.nobelprize.org/prizes/physics/2022/summary/>

Permalink: <https://detailenjoyer.com/case/entanglement/> · Last updated Nov 14, 2023



DD-338 SCIENCE · 10 OF 11

QUANTUM SHENANIGANS

The Schrödinger equation, published by Erwin Schrödinger in 1926, is a central equation of quantum mechanics. It describes how a system's wave function evolves over time; the square of the wave function's magnitude gives the probability of finding a particle in a given place. The footage shows animations of waves and particles.

QUICK FACTS

DD-338-F01

It is central to quantum mechanics.

DD-338-F02

Schrödinger published it in 1926.

THE WRITE-UP

Equation. It is central to quantum mechanics.

1926. Schrödinger published it in 1926.

Evolution. It describes change over time.

Wave function. It governs the wave function.

Probability. The wave function gives probabilities.

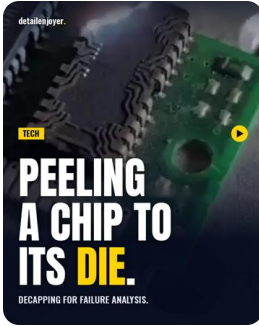
REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Schrödinger equation: https://en.wikipedia.org/wiki/Schr%C3%B6dinger_equation

Permalink: <https://detailenjoyer.com/case/quantum-shenanigans/> · Last updated Oct 5, 2024



DD-389 TECH / SCIENCE · 11 OF 11

A LOOK INSIDE

Decapping removes the plastic or ceramic package from an integrated circuit such as a RAM chip to expose the silicon die. It is usually done with hot acids such as fuming nitric or sulfuric acid, or by milling or laser ablation. The exposed die can then be inspected under optical or electron microscopes for failure analysis, quality checks or reverse engineering. The footage shows a memory chip being opened and its die magnified.

QUICK FACTS

DD-389-F01

Exposes the die.

DD-389-F02

Nitric or sulfuric acid.

THE WRITE-UP

Purpose. Exposes the die.

Acids. Nitric or sulfuric acid.

Mechanical. Milling or lasers.

Inspection. Microscopes.

Uses. Failure analysis.

REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Decapping: <https://en.wikipedia.org/wiki/Decapping>
2. Wikipedia: Die (integrated circuit): [https://en.wikipedia.org/wiki/Die_\(integrated_circuit\)](https://en.wikipedia.org/wiki/Die_(integrated_circuit))

Permalink: <https://detailenjoyer.com/case/a-look-inside/> · Last updated Nov 24, 2024

COLLECTION QUIZ

Test Your Knowledge: 22 questions from From Transistors to Qubits. Answers are on the next page.

1. How many transistors did Intel's 4004, the first commercial microprocessor (1971), have? (DD-018

· Shrinking Circuits)

- A. 23
- B. 2,300
- C. 230,000
- D. 2.3 million

2. What process feature size was the Intel 4004 made with? (DD-018 · Shrinking Circuits)

- A. 10 micrometers
- B. 10 nanometers
- C. 1 millimeter
- D. 100 nanometers

3. In which Texas county is Terafab planned? (DD-016 · TeraFab)

- A. Grimes County
- B. Travis County
- C. Harris County
- D. Bastrop County

4. How big is the first-phase investment announced for Terafab? (DD-016 · TeraFab)

- A. About \$1.68 billion
- B. More than \$16.8 billion
- C. About \$168 billion
- D. \$119 billion

5. What is the gold 'chandelier' seen in photos of quantum computers? (DD-012 · Quantum Infrastructure)

- A. A dilution refrigerator
- B. A cooling fan array
- C. The quantum processor itself
- D. A power supply

6. Where in the fridge does the quantum chip sit? (DD-012 · Quantum Infrastructure)

- A. At the top, at room temperature
- B. In the middle
- C. At the bottom, on the coldest plate
- D. Outside the fridge

7. Roughly how tall is a Panthalassa Ocean-3 node? (DD-022 · Ocean-3)

- A. About 8.5 m
- B. About 25 m
- C. About 85 m
- D. About 850 m

8. How does Ocean-3 make its electricity? (DD-022 · Ocean-3)

- A. Solar panels on the sphere
- B. Seawater forced up its tube by the waves spins turbines
- C. A small diesel generator
- D. A power cable from shore

9. Roughly what share of the world's electricity did data centers use in 2024? (DD-029 · Data Centers)

- A. 0.1%
- B. 1.5%
- C. 10%
- D. 25%

10. Which country used the most data-center electricity in 2024? (DD-029 · Data Centers)

- A. China
- B. India
- C. United States
- D. Germany

11. Which molecules were moved to make the film? (DD-663 · Atomic Stop-motion)

- A. Carbon monoxide
- B. Water
- C. Carbon dioxide
- D. Helium

12. What tool moved the molecules? (DD-663 · Atomic Stop-motion)

- A. Scanning tunneling microscope
- B. Optical tweezers
- C. Electron beam welder
- D. Laser cutter

13. What was the Analytical Engine? (DD-095 · Ada All-Time)

- A. A proposed mechanical computer
- B. A steam train
- C. A telescope
- D. A loom

14. What language did Lovelace translate from? (DD-095 · Ada All-Time)

- A. French
- B. German
- C. Latin
- D. Italian

15. What are chips built on? (DD-238 · The Future Is Now)

- A. Silicon wafers
- B. Glass plates
- C. Copper sheets
- D. Silicone rubber

16. What coats the wafer? (DD-238 · The Future Is Now)

- A. Photoresist
- B. Paint
- C. Oil
- D. Gold

17. What do entangled particles share? (DD-080 · Entanglement)

- A. A quantum state
- B. A charge only
- C. A color
- D. A mass

18. Does distance break the correlation? (DD-080 · Entanglement)

- A. No
- B. Yes
- C. Only over 1 km
- D. Only in water

19. Who published the equation? (DD-338 · Quantum Shenanigans)

- A. Erwin Schrödinger
- B. Albert Einstein
- C. Niels Bohr
- D. Isaac Newton

20. When? (DD-338 · Quantum Shenanigans)

- A. 1926
- B. 1905
- C. 1687
- D. 1969

21. What does decapping expose? (DD-389 · A Look Inside)

- A. The silicon die
- B. The battery
- C. The screen
- D. The fan

22. Which acid is used? (DD-389 · A Look Inside)

- A. Nitric
- B. Citric
- C. Acetic
- D. Lactic

ANSWER KEY

1. **B. 2,300** Now You Know: The 4004 squeezed 2,300 transistors onto one chip. (DD-018)
2. **A. 10 micrometers** Now You Know: The 4004 used a 10 μm silicon-gate pMOS process. (DD-018)
3. **A. Grimes County** Now You Know: Terafab is planned for Grimes County, about 20 miles east of College Station. (DD-016)
4. **B. More than \$16.8 billion** Now You Know: The first phase is a capital investment of more than \$16.8 billion; \$119B is the potential four-phase total. (DD-016)
5. **A. A dilution refrigerator** Now You Know: It's a multi-stage dilution refrigerator, and each plate down is colder. (DD-012)
6. **C. At the bottom, on the coldest plate** Now You Know: The processor is mounted on the mixing-chamber plate, the coldest stage, at the bottom. (DD-012)
7. **C. About 85 m** Now You Know: Each node is about 85 m of plate steel, close to the height of Big Ben. (DD-022)
8. **B. Seawater forced up its tube by the waves spins turbines** Now You Know: As waves lift and drop the node, seawater is driven up the tube into the sphere, where it spins turbines. (DD-022)
9. **B. 1.5%** Now You Know: The IEA estimates about 415 TWh, roughly 1.5% of global electricity. (DD-029)
10. **C. United States** Now You Know: The U.S. accounted for about 45%, ahead of China (25%) and Europe (15%). (DD-029)
11. **A. Carbon monoxide** Now You Know: Carbon monoxide, on copper. (DD-663)
12. **A. Scanning tunneling microscope** Now You Know: A scanning tunneling microscope (STM). (DD-663)
13. **A. A proposed mechanical computer** Now You Know: Designed by Charles Babbage. (DD-095)
14. **A. French** Now You Know: Menabrea's article. (DD-095)
15. **A. Silicon wafers** Now You Know: Very pure silicon. (DD-238)
16. **A. Photoresist** Now You Know: Light-sensitive. (DD-238)
17. **A. A quantum state** Now You Know: One state. (DD-080)
18. **A. No** Now You Know: Any distance. (DD-080)
19. **A. Erwin Schrödinger** Now You Know: Austrian physicist. (DD-338)
20. **A. 1926** Now You Know: Early quantum era. (DD-338)
21. **A. The silicon die** Now You Know: Inside. (DD-389)
22. **A. Nitric** Now You Know: Strong. (DD-389)

NOW YOU KNOW!