Missile technology

Hypersonic boom

BERLIN AND WASHINGTON, DC

Long range, gliding missiles that fly at more than five times the speed of sound are coming

"'Once the rockets are up, who cares where they come down?/ That's not my department!' says Wernher von Braun."

TOM LEHRER'S satirical ditty on the Nazi-turned-American rocketeer was faithful to the essence of early missile development, whose principal challenge was hoisting the weapons into the sky. Gravity did most of the rest. The first warheads capable of steering on descent did not arrive until the 1980s. Even they were limited in how much they could move around, making it pretty easy to predict their target area.

A new generation of hypersonic missiles is changing all that. Some might be capable of gliding across continents at great speed, their target unpredictable until seconds before impact. Russia claims to have a hypersonic glider on the cusp of deployment; others are redoubling their efforts. Many are likely to start entering service in the 2020s. All this opens up new military possibilities—and problems.

Missiles that travel at speeds greater than Mach 5 (five times the speed of sound, or about 1.5km per second), have existed for some time. Intercontinental ballistic missiles (ICBMs) re-enter the atmosphere at up to 8km per second. What is different about the hypersonic weapons in the pipeline is that they are designed to sustain such speeds over long distances, manoeuvre as they do so and, in some cases, hit targets with pinpoint accuracy.

"Manoeuvrable missiles travelling at many times the speed of sound barely leave time for considered human responses," warned Heiko Maas, Germany's foreign minister, in March. Such weapons may also elude today's arms-control agreements, which were written for an earlier generation of weapons.

There are two basic designs: cruise missiles and gliders. Hypersonic cruise missiles are essentially faster versions of existing ones but powered by very different jet engines. Gliders are pricier and harder to build, but can travel faster and farther, and so are receiving more attention. Like ICBMs and von Braun's V-2s, they are lofted into space and fall to earth unpowered. But unlike the old-fashioned projectiles, they do not follow a predictable, parabolic arc through the sky. Instead, a hypersonic glide vehicle (HGV) detaches from the rocket while it is still ascending and either skips along the upper atmosphere or, having re-entered, glides through it for hundreds or thousands of kilometres.

Such gliders have several advantages. Ballistic missiles are less agile and tend not to be very accurate. A Minuteman III ICBM, the backbone of America's nuclear arsenal, has a "circular error probable" of roughly 120m, meaning only half the missiles fired are expected to land within 120m of the impact point. That is fine for nuclear bombs but useless for hitting a ship or runway. Today's cruise missiles, on the other hand, are very accurate—one could be sent through a window—but much slower. HGVs combine the speed of ballistic missiles with the manoeuvrability and accuracy of cruise missiles. "You can fly, you can shape your trajectory, you can turn," says Will Roper, the US Air Force acquisitions chief.

The key is their trajectory. An unpowered ICBM warhead spends most of its time in the vacuum of space where it cannot duck or dive, but HGVs spend 80% of their time below 100km, allowing them to manoeuvre for most of their flight. They can also dodge ground-based radar for longer by hiding behind the curvature of the Earth. Whereas American ICBMs must fly over Russia to hit China—which could lead to dangerous misunderstandings—gliders could take more circuitous routes, avoiding missile defences and leaving adversar- ▸▸

ies uncertain of the target.

Hypersonic gliders are almost a century in the making. The first rocket-boosted glider flew in Germany in 1928. During the second world war, German engineers tried to extend the range of von Braun's V-2 by having it glide. After the war, America and the Soviet Union pilfered German rocketry, leading to a series of technological leaps. Alpha Draco, an American HGV, was tested to hypersonic speeds in the 1950s and hypersonic gliding was refined by the space race: the space shuttle was a hypersonic glider, in its way.

War at Mach 5

Why, then, have hypersonic missiles taken so long to arrive? Extended hypersonic flight presents fiendish scientific and engineering challenges. The lift-to-drag ratio of the space shuttle at hypersonic speeds is around one, notes James Acton of the Carnegie Endowment, a think-tank; an advanced glider would require over twice that. Higher lift-to-drag ratios require sharp leading edges, which, combined with extreme velocities, can generate surface temperatures up to 2,000°C. That can erode a glider's protective coating, fry its electronics and bend it out of shape. America's test of one prototype in 2011 failed when the skin blistered and peeled off. The resulting shockwaves overwhelmed control systems in less than two seconds.

The only thing that seems to work, says an expert at an arms company that is developing gliders, is to cover the vehicle in cork. But that is vaporised in minutes or less, so does not work for long-range missiles. Dissipating heat as quickly as it is built up is "daunting" and "perhaps impossible" above Mach 10, he says.

Great speeds also break up molecules in the atmosphere, creating a field of charged particles (or "plasma") around the glider, which disrupts GPS and other signals required for guiding the missile to its target. Researchers "still don't completely understand the physics of hypersonic flight", wrote Ivett Leyva of America's Air Force Office of Scientific Research in a 2017 paper.

The big powers have all made some progress in surmounting these challenges. Thomas Bussing, who heads missile development for Raytheon, an arms company, says there has been a "step change" over the past decade, thanks to advances in computational fluid dynamics, new materials and electronic and guidance systems. America, which set aside $2.6bn for hypersonic weapons in the Pentagon's 2020 budget, is probably farthest ahead. It tested a wedge-shaped glider in 2010 and 2011, a more successful cone-shaped design in 2011, 2014 and 2017 (the Alternate Re-entry System) and is working on tactical systems that use smaller, cheaper rockets and could be launched from ships and aircraft.

Russia has been working on hypersonics for decades, haltingly. Its flagship Avangard glider was flaunted publicly by President Vladimir Putin in March 2018 and tested to great fanfare in December, after which it was declared ready for service this year—somewhat implausibly, say experts. Pavel Podvig of the United Nations Institute for Disarmament Research points out that very few of the glider's tests were successful and that the programme was nearly shut down four years ago.

China has tested its own DF-ZF HGV at least nine times since 2014. Almost nothing is publicly known about its nimbleness or accuracy. Australia, India, France and Japan are all chasing the pack. "We have lost our technical advantage in hypersonics," warned General Paul Selva, America's highest-ranking air-force officer in January. China has built two to three times as many hypersonics-related facilities as America, including the world's fastest wind tunnel for testing, and pumped out the most public research on the technology (716 publications in 2017, compared with 207 from America and 76 from Russia).

Even so, Mr Acton suggests that the Chinese programme is probably less advanced than America's. For one thing, America is testing its gliders over significantly longer ranges than China is. It is also solving a different, harder, problem. America wants the ability to deliver conventional warheads over continental distances. It is because ICBMs are not accurate enough for this that it wants HGVs. Russia and China are keener on nuclear-tipped ones, partly because they fear their existing nukes might one day be stopped by improvements in America's missile-defence shield. Their own gliders need not be so precise.

Douglas Barrie, an expert at the International Institute for Strategic Studies, a think-tank, forecasts that hypersonic gliders are likely to start entering service in the early 2020s. The result might be twitchier decision-makers and a more frenzied battlefield.

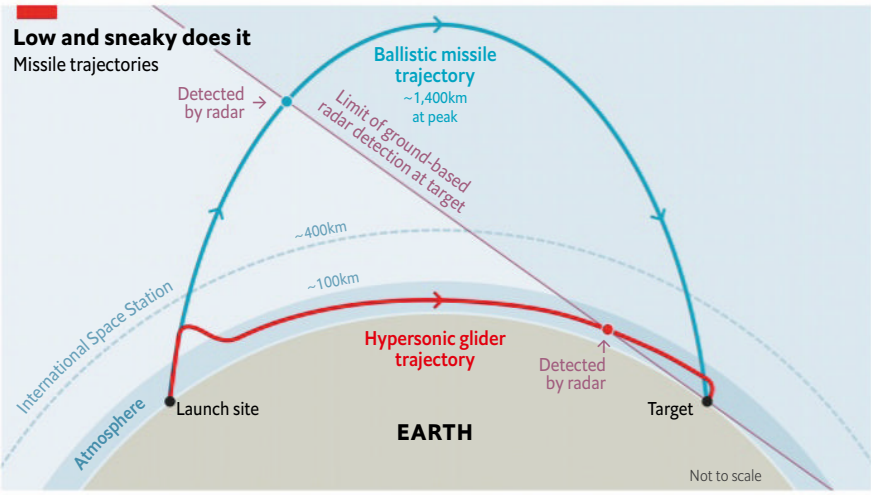
Area defences, which guard broad swathes of territory like continental America, rely on shooting down missiles mid-course and on a straightforward trajectory. Gliders do not go as high and are less predictable, hence Mr Putin's boast that the Avangard is "invulnerable to interception" (some reckon that interceptors placed in space might have a shot as super-hot gliders should stand out to infra-red sensors).

Point defences, which guard individual sites against shorter-range missiles, might have more luck. Gliders must slow down as they approach their targets. Systems like America's THAAD have a proven ability to shoot down ballistic missiles, which close in more quickly.

"The world has changed dramatically," says Mr Bussing. "These systems are very, very difficult to counter and fundamentally give the holder a tremendous advantage over the states that don't have them. The sense of urgency to develop ways to counter them is an imperative."

One American military official suggests that humans will have to hand ever more control to defences that are already semi-autonomous: "There will be no time at all for a man in the loop." The uncertain payload of gliders is another problem. If targets could not tell the difference between conventional and nuclear gliders, or feared that conventional ones, through accuracy and kinetic energy alone, could threaten important targets, they might choose to launch their own nuclear forces to avoid losing them.

There are also wider implications for arms control. The impending collapse of the Intermediate-Range Nuclear Forces (INF) Treaty, which barred America and Russia from possessing land-based missiles of 500km-5,500km ranges, clears the way for both countries to develop and deploy new ground-launched hypersonic missiles. A separate treaty, New START, caps the number of longer-range weapons,



but is up for renewal in 2021 and looking shaky. When it was negotiated in 2010, America and Russia implicitly agreed that gliders would not be covered. Former officials say that was a mistake.

Germany convened an arms-control conference in Berlin on March 15th to kick-start a discussion on taming the risks posed by futuristic weapons, including hypersonic missiles, through diplomacy. Mr Maas called for an "international missiles dialogue" to discuss the challenge.

The UN's disarmament office has proposed that rivals could swap information on test flights and take other confidence-building measures. Corentin Brustlein of IFRI, a French think-tank, suggests capping glider numbers. Yet America and Russia are enmeshed in worsening disputes over today's weapons, let alone tomorrow's, and China shows little interest in tying its hands. Gliders are likely to enjoy a fair geopolitical wind. ■

E-health

Don't be still, my monitored heart

What happens when your watch tracks your pulse?

ON THE MORNING of March 28th, the owners of newish Apple Watches in 19 countries woke up to find their timepiece was now a medical device. Two new features arrived. One monitors the wearer for an irregular pulse. The other allows a brief but detailed electronic portrait, or ECG, to be captured and inspected for signs of a common heart arrhythmia called "atrial fibrillation", or AFib.

Americans have had these options since December, but their global expansion puts the technology squarely within the purview of public-health systems, which typically think carefully about how to screen for health conditions. The watch is also spurring debate about how doctors should handle the AFib that it and other consumer devices, such as AliveCor, detect.

AFib is the most common cardiac arrhythmia and occurs when the heart's upper chambers do not beat in a co-ordinated fashion. Blood can pool in parts of the chambers and form clots. Patients with AFib are five times more likely to have a stroke. They can be treated successfully with blood-thinners, but these carry risks, primarily excessive bleeding. AFib is thought to occur in 2% of the population. However, as the risk of suffering from it increases greatly with age, it will be rare in Apple Watch owners, who are younger, richer and healthier.

Jonathan Mant, a professor of primary-care research at the University of Cambridge, runs a study of the over-65s that is hoping to discover if AFib screening can prevent stroke and other problems, such as heart attacks or even dementia. Dr Mant says AFib, picked up clinically, is important and worth treating, but that may not be true of the cases found by the watch. "We really have no idea what that would mean," he says.

Some public-health scientists have warned that AFib screening leads to many false positives and negatives, and these problems could be made worse by consumer technologies. Carl Heneghan, a professor of evidence-based medicine at the University of Oxford, says these new technologies bypass the usual governance systems that ensure new screening programmes do not create harm. He also worries that false positives will generate a huge amount of pointless work.

The recent "Apple Heart Study", covering 420,000 patients, looked at the predictive value of the device's monitoring for irregular pulses. It found that the watch only agrees with a gold-standard method 84% of the time. The feature is intended to prompt wearers to use the ECG app, which is designed to deliver a diagnosis. A study conducted by a research organisation contracted by Apple found the app's algorithm was able to correctly identify 98.3% of true positives and 99.6% of true negatives.

Yet neither trial included randomised ▸▸

Acoustics

Hear, hear

Some political noise really is just that

BEING HEARD in Britain's House of Commons is not always essential to get things done. One of the most influential and famous speeches was made there 230 years ago next month, when William Wilberforce denounced slavery and kick-started the abolitionist movement. Yet a new study suggests many MPs in the audience wouldn't have been able to hear him properly.

Catriona Cooper, a digital archaeologist at the University of York, used a computer model to recreate the acoustics of the 18th-century Commons, which was housed in the former St Stephen's Chapel. Then, using reports of how many people were in the building at the time and where they would have sat or stood, she worked out how Wilberforce's speech on May 12th 1789 would have sounded to those present.

Many in the chamber would have been distracted by booming echoes, the model suggests. And those MPs in the best seats, including the front benches, would have heard worst of all. To them, Wilberforce's fine rhetoric would have been a mush of rebounded sound. In fact, the best places to listen to this and other Georgian debates in the Commons were largely out of sight, in the doorway or behind the Speaker's chair.

Dr Cooper's model, whose results are published in *Parliamentary History*, suggests that in 1798 the chamber had an average reverberation time—a measure of how slowly sound dissipates—of 1.6 seconds. A lower number means less echo, and the optimal reverb time for spoken words is less than a second. St Stephen's Chapel sounded more like an opera house (which typically aims for a reverb time of 1.3 to 1.8 seconds).

Best seat in the house

It burned down in 1834, but the acoustics of the modern House of Commons remain notoriously poor, and that's not all down to the braying and heckles. High ceilings and stripped-down furnishings encourage echoes. Blame Winston Churchill for some of that. After the Commons was destroyed by German bombs in 1941, he ignored suggestions for a design that was more fit-for-purpose and insisted it be rebuilt faithful to its previous "intimate and conversational" style. The next chance to improve things will be in 2025, when the Palace of Westminster is scheduled for a long-overdue update. Whether that will improve British political affairs is open for debate.

controls, which would offer the kind of information doctors want. This is now planned among the over-65s. There is also an urgent need to understand how common intermittent AFib is, and its consequences. This is something the watch might help with, by providing reams of data that are otherwise difficult to come by.

Matt Kearney, the National Clinical Director for Cardiovascular Disease Prevention for Britain's National Health Service, admits there are challenges with the watch and the rise of consumer-health technologies more generally. But he says the device will uncover cases of AFib that need treatment, and in younger people who have no other symptoms it will be an "opportunity for people to be advised about their risks".

Health professionals will need to embrace new technologies, if only because they are inevitable, Dr Kearney adds. And health systems will need to adapt to the torrent of data. As for the broader impact of the Apple Watch, Dr Mant concludes it is "paradigm-shifting. I just don't know if it is going to be in a good way or a bad way." ■

Mass extinctions

Day of reckoning

Stony evidence of the hellfire that drove dinosaurs to extinction

When, in 1980, Luis Alvarez, a physicist, and his son Walter, a geologist, made public their theory that the dinosaurs were killed by a massive asteroid strike, it came as a curveball to palaeontologists, who believed dinosaurs had gradually died out through other means. The father-and-son team from the University of California, Berkeley, argued that evidence of the catastrophe was hiding in plain sight, the world over, as a thin layer of sediment enriched in iridium, a metal commonly found in asteroids but rare on Earth. They pointed out that no dinosaurs, with the exception of birds, were ever found beyond this critical layer and suggested a devastating impact was responsible.

The only piece of the puzzle that has been missing is evidence of what actually happened when the asteroid struck. Now, almost 40 years later, an American fossil bed is revealing details of the raging hellstorm that followed just minutes after the asteroid impact, and eventually drove the dinosaurs to extinction.

Under most circumstances, fossils form when animals die in places like river deltas where fine sediment slowly covers up their bones and ultimately encases them in rock. Not so at the aptly named Hell Creek formation of Tanis in North Dakota. Here, Robert DePalma, a PhD student at the University of Kansas, and a team of colleagues that includes Walter Alvarez are reporting the discovery of a 1.3-metre-thick sedimentary layer that was catastrophically dumped in a single day.

The layer is loaded with the bodies of marine and freshwater fish. This alone struck Mr DePalma as odd since Hell Creek is not known for the preservation of brackish ecosystems where such animals could mingle. But what proved truly unnerving was the fact that all of the bodies were intact, faced the same direction and were scattered among felled tree trunks. That hinted at a sudden surge of water: the streamlined shape of fish means they automatically orient themselves with their heads pointing into a current of fast-moving water. That the bodies were all intact suggests that they were rapidly buried. Moreover, only the most powerful of currents can knock trees down, so the assemblage must have formed during a single devastating event.

Wedged between a 66m-year-old layer of Cretaceous sediment, and another dating from the subsequent Tertiary period, when mammals came to dominate Earth, the Hell Creek fossils are in the perfect position to record the moments that immediately followed the asteroid impact.

Supporting this, spheres of what was once molten glass and fragments of quartz generated under exceptionally high pressures and blasted into the air are scattered throughout the site. Some of it was lodged inside the gills of fossilised fish. Presumably, they sucked it in with their last desperate gasps. The bottom layer of the site contains burrows that appear to have been dug by mammals and are filled with coarse sand brought in over land at great speed, the signs of which are seen in the ripples left in the sand. Dusting the top of the formation is an ominous layer of iridium.

Other fossil finds, yet to be confirmed, include fish impaled on the spines of one another, wasp nests, flooded ant hills, ancient primates and the leaves of plants probably related to the modern banana tree. The team are studying these but their findings have yet to be peer-reviewed and so are not included in the discovery's scientific announcement, which was published by *Proceedings of the National Academy of Sciences* last week.

What is clear already from the confirmed evidence is the sequence of events that unfolded in the minutes and hours after the asteroid hit. It struck the Mexican coast, sending enormous volumes of gas and molten material into the atmosphere, and igniting a firestorm that would have engulfed much of the planet. Its impact crater, located beneath the Yucatan peninsula and the southern Gulf of Mexico, has been a focus of scientific interest for many years. Undoubtedly, this would have created an enormous tsunami, but Mr DePalma suspects that the Tanis fossils, located thousands of kilometres to the north, were killed by a different phenomenon, triggered by the impact: a seiche wave.

Also known as standing waves, seiche waves form in large bodies of water that are either steadily blown by strong winds or shaken by tremors. Mr DePalma and his colleagues propose that the asteroid impact shook Earth so forcefully that seiche waves as tall as 100 metres rose up in every large body of water across the planet, including the shallow sea near Tanis.

Further fossil evidence will be needed to prove the theory, but if Mr DePalma is correct then the inferno initiated by the impact was made worse by devastating walls of water everywhere. No wonder the dinosaurs threw in the towel. ■

A fishy finish

Jewish-American culture

Chronicle of the golden land

NEW YORK

The history of the *Forward* is a parable of Jewish intellectual life in America

THEY CAME, for the most part, from a cloistered world that time and tragedy have dissolved. It was circumscribed by dogma and poverty and revolved around ritual. From homelands with names that have faded from maps of Europe—Galicia, Bessarabia, the Pale of Settlement—they traversed hostile countryside, boarded trains to Hamburg and Bremen, and packed into ships bound for *di goldene medine*.

Between 1880 and 1924 as many as 2.5m Jews came to America from eastern Europe. They were not the country's first Jewish citizens: Sephardim (Iberian Jews) arrived in small numbers in the colonial period, and among the immense 19th-century wave of German immigrants were around 250,000 Jews. But this later cohort formed the foundation of what grew into a recognisably Jewish-American culture.

On the whole the immigrants were poor but relatively well educated: Judaism prized argument and exegesis, which require literacy. In daily life they spoke and read Yiddish (Hebrew was the language of prayer), a hybrid tongue perfectly suited to expressing what Irving Howe, a Jewish-American historian, called the "distinctive traits of the modern Jewish spirit at its best ...an eager restlessness, a moral anxiety, an openness to novelty, a hunger for dialectic, a refusal of contentment, an ironic criticism of all fixed opinions."

In 1897, a decade and a half after arriving in New York from Vitebsk (now in Belarus), a young socialist and writer named Abraham Cahan founded the *Jewish Daily Forward*—the *Forvertz* in Yiddish, the language in which it was published. By the mid-1920s its daily circulation was higher than that of the *New York Times*. Mostly read in and around New York, it had followings in Boston, Chicago, Detroit and Philadelphia and as far afield as Buenos Aires, Berlin, Warsaw and Tel Aviv. No Jewish periodical anywhere had a larger circulation than the *Forward* until *Maariv*, an Israeli paper, overtook it in 1968. It was based in the Lower East Side, the epicentre of Jewish America, but had bureaus across the country. An array of Jewish writers contributed, including Isaac Bashevis Singer, the sole Yiddish Nobel laureate for literature, who maintained his *Forward* column until 1991.

The *Forward* expanded into radio. Its station, WEVD, was named in honour of Eugene V. Debs, a five-time presidential candidate from the Socialist Party of America. The paper, and its readers, were so steeped in Yiddish that it did not publish an English edition until 1990. But it was not parochial. As Seth Lipsky, who launched that English edition, explains: "It was a general-interest daily in the Jewish language." Unsurprisingly, it thrived on argument, and never shied from slaughtering a sacred cow. Despite his early socialist views, Cahan swiftly turned on Bolshevism; he visited the Soviet Union in 1927 and found life there even worse than it had been under the tsars.

The newspaper had an intimate side. It ran an advice column called "A Bintel Brief" ("A Bundle of Letters"), which began answering readers' questions about their bewildering new country in 1906. The letters, and their answers, took a deeply Jewish, morally practical tone. "I am a 'greenhorn', only five weeks in the country," explained one young man. "I come from Russia, where I left a blind father...I promised that I would send him the first money I earned in America." The writer has managed some modest savings, but his work is tenuous. "I want you to advise me what to do. Shall I send my father a few dollars for Passover, or should I keep the little money for myself," as a safeguard against future penury? "The answer to this young man", explained the editor paternally, "is that he should send his father the few dollars [because] he will find it easier to earn a living than will his blind father in Russia."

Another correspondent, another sticky situation. He is "a Russian revolutionist ▸▸

and a free thinker" who is about to marry. The problem is that his in-laws are still hooked on the opiate of the masses. Should he stick to his principles and alienate them, or grit his teeth through a synagogue marriage? The *Forward*'s advice—"there are times when it pays to give in to old parents"—will resonate with anyone who has endured overbearing elders.

The Russians were coming

Jewish immigration slowed after Congress passed the Immigration Act of 1924, which admitted newcomers in proportion to their nationality's presence in America in 1890. During the second world war millions of potential emigrants were reduced to ash. Meanwhile second- and third-generation Jews whose families had made it to the golden land began to assimilate (including in their reading matter), as the Germans and Irish did before them. Yiddish became the language of the dwindling older generation—viewed from Jewish suburbs with affectionate nostalgia, as an ornament of comedy sketches rather than an everyday tongue. By the 1980s the *Forward*'s acculturative function was becoming superfluous. Some Jews were still arriving, but as J.J. Goldberg, who succeeded Mr Lipsky as the editor of the English edition, summarises, "they were assimilated Russians coming to become assimilated Americans."

For a time the *Forward* published a Russian edition. A Jewish-American journalist who worked under Mr Lipsky fondly recalls the mix of staff: Hasidim from Brooklyn who laboured in Yiddish; secular American Jews who put out the English edition; fast-talking, conspiracy-minded Russians who wrote in their language. Even as the Yiddish readership aged and the Russian edition was sold in 2004, the *Forward* soldiered on. But paper is expensive, the industry is changing and everything must end: the last print copies will roll off the presses in April or May. The building in Manhattan that was once the paper's headquarters now houses condominiums.

This does not mark the end of the Yiddish press: *Di Tzeitung* is published weekly in Brooklyn and caters to Hasidim, many of whom still reserve Hebrew for liturgy as their ancestors did, and wish to hold the secular American world at bay. Nor, even, does it mark the end of the *Forward*, which will continue as an online publication in both English and Yiddish. The business, says its publisher, Rachel Fishman Feddersen, remains "on firm financial footing", committed to its mission "to create the best independent journalism and protect the Jewish-American soul".

But in an age of atheism and intermarriage, what is that soul, and how best to protect it? That is the beginning of an argument—one that Abraham Cahan would surely have loved. ■

This great stage

Ripeness is all

NEW YORK

A mighty actor's Lear is the thing itself

GLENDA JACKSON has a reputation for asperity. As a star of stage and screen, she earned notoriety and two Academy awards for her knack for finding something wise and sharp in even middling scripts. A profile in 1971 heralded her as "the screen's champion castrator". As a left-wing Labour backbencher for over two decades until 2015, she regularly skewered Tony Blair and took Margaret Thatcher's death as an opportunity to lambast her. Yet it is hard to be intimidated on meeting Ms Jackson (pictured) at her New York haunt of choice—a humble Manhattan diner—where she is dressed in what she calls her "work gear": a shabby Tintin sweatshirt and no makeup.

In person, she is less harsh than self-assured. Perhaps because she is a woman, her fierce and unapologetic intelligence has earned comparisons to a schoolmistress, but her assertiveness is more puckish than pedantic. In a voice that nearly growls after a lifetime of smoking, she speaks with refreshing candour about her return to Broadway to star in "King Lear", directed by Sam Gold, which opens at the Cort Theatre on April 4th.

As well as, in the past, being overwhelmingly reserved for men, the role of Lear is often thought too demanding for actors close in age to the geriatric patriarch. Few have the stamina to disintegrate on stage for over three hours, racked by time, betrayal and hubris. With a dismissive wave, Ms Jackson quickly rejects the notion that, at 82, she might find it taxing to shoulder Shakespeare's tragedy eight times a week: "There's an energy in the play which gives you energy." She commands the part with electrifying charisma, at once vitriolic and vulnerable, grandly trilling her Rs and—always convincing when she is cruel—wielding her words like a scythe. Yet Lear's encroaching impotence leaves her slicing at air. Stripped of most of her clothes and nearly all of her power, she is a hauntingly mortal figure on spindly legs.

After a quarter of a century away from the stage, Ms Jackson's turn as Lear in London in 2016 made it clear that time had burnished her original craft. Last year she won a Tony for her performance as an acidic widow in Edward Albee's "Three Tall Women". With disarming humility, she admits she is surprised to be getting such good roles again. She recalls her first years after graduating from the Royal Academy of Dramatic Art, when her unconventional looks and "unemployable accent"—she grew up in north-west England—made it hard to find work. "Every time I finished a job I thought, I'm never going to work again. That doesn't go away." Mr Gold admires her for "a work ethic that goes beyond anyone I've worked with before." For Ms Jackson, such dedication is part of her inheritance. "I come from a socio-economic group where if you didn't work, you didn't eat."

In this production, Lear's court is gilded in an unmistakably Trumpian splendour. The fool (a delightful Ruth Wilson) wears socks printed with the American flag. "I think we need to see what happens when an autocrat's madness gets taken to its logical extreme," Mr Gold says of the play's calamitous ending. Casting a female Lear unexpectedly amplifies the sense of male privilege. Ms Jackson's version is generally androgynous—less a man or a woman than a human undone by human frailty—but the king's shock at his waning power seems terribly male. It is hard to imagine a woman going to such lengths to lament the loss of a supremacy that she never truly had.

It is not lost on Ms Jackson that so many of the best roles are still written for men. "There are a lot of very good contemporary dramatists around, but they don't find women interesting." She does not seem impressed by the cascade of sackings that have followed the #MeToo revelations. "It makes you laugh, doesn't it? Did people really not know it was going on?"

Acting, she says, is sadomasochistic. "Every night is the first time," she explains. "A performance has to be alive every time." It's hard work, and she is not always sure why she does it. But at its best it involves a group of strangers in the light sending their energy to a group of strangers in the dark, "and when it works that energy is strengthened and sent back to you in a kind of perfect circle. It's a unique experience." ■

Petals and politics

Flower power

The Englishman who helped safeguard Japan's cherry trees

On March 21st a Japanese phenologist observed the pink-and-white blossoms on a cherry tree in the Yasukuni shrine in central Tokyo and formally declared the start of the cherry-blossom viewing season. There are many of this type of cherry, known as *somei-yoshino*, in the shrine that honours Japan's war dead. Some are so old they are held up by wooden struts. In Japan's militaristic mythology, the petals represent the souls of dead fighters.

Few of those currently visiting Japan would associate the delicate flowers with the cruelty of war. More likely they will swoon over nature's ephemeral beauty and, like their hosts at this time of year, drink wildly. Yet the *somei-yoshino* has a dark past, which Naoko Abe explains in her lovely book, "The Sakura Obsession". It is also the story of a quintessentially English nature lover, Collingwood "Cherry" Ingram, who was one of the first to grasp the *somei-yoshino* cherry tree's dangerous seductiveness, and to attempt to tame it.

Cherry trees come in hundreds of forms. In the mountains of Japan, the lordly *yama-zakura*, for instance, is one of a few wild cherries. But in the cities, the vast majority are *somei-yoshino*, a cloned variety that flowers for a mere eight days or so in spring, evoking syrupy delight as its mist of pink blossoms billow in the wind. As Ms Abe tells it, the tree was first hybridised in the 1860s, just as Japan was emerging from a 400-year period shut off from the outside world by its rulers. After the fall of the shogunate, its outward-looking leaders needed a symbol of unity and modernisation. The *somei-yoshino* "fitted the bill perfectly".

Ingram was a cherry devotee. Shortly after returning from the first world war, the middle-aged country toff decided to plant as many cherry varieties as he could find in his large garden in Kent. He imported seeds, grafted scions onto root stock, and worked feverishly to understand the naming system of Japanese cherry trees. In 1926 his quest took him to Japan, almost 25 years after he had first visited the country as a young man and been smitten by its beauty.

He was no idle enthusiast. He soon realised that an extraordinary variety of cherry trees cultivated during 2,000 years of tree-worship in Japan were in danger of being lost in favour of one, the *somei-yoshino*. Not only did he relate this in a blunt speech to the titans of Japanese industry at Tokyo's Imperial Hotel. He also promised to help Japan restore more variety by sending stock back from his garden.

The Sakura Obsession. By Naoko Abe. *Knopf; 400 pages; $27.95. Published in Britain as "'Cherry' Ingram: The Englishman Who Saved Japan's Blossoms" by Chatto & Windus; £18.00*

Two tensions animate this book: the difficulty of sending fragile scions around the world and successfully grafting them; and the wrenching historical context. As Ingram battled to safeguard Japan's cherry legacy, the country was succumbing to belligerent nationalism. Many loathed the idea of relying on a Westerner to recover its botanical heritage. Moreover, the *somei-yoshino* cult was just getting into its swing. Within 20 years, *kamikaze* pilots would fly to their doom with cherry blossoms painted on their fuselages. After death, they were promised, they would be reborn as blossoms at Yasukuni.

Be warned. It is hard to view the blossoms of the *somei-yoshino* with such tender joy after reading Ms Abe's book. On the other hand, visitors to Japan will yearn to see more of the *yama-zakura*, great-white cherries and other varieties that Ingram so devotedly helped to rescue.

These days Japanese people increasingly bemoan the tide of foreigners, especially from China, who join their *hanami*, or cherry-blossom viewing parties. Perhaps commentaries like Ms Abe's will inspire them to cultivate other cherry trees, which flower earlier or later, and delight in their variety, as their ancestors did centuries ago. ■

Pretty in pink

Exercise and exploration

Feet first

Walking: One Step at a Time. By Erling Kagge. Translated by Becky Crook. *Pantheon; 192 pages; $19.95. Viking; £9.99*

Have you ever been so heartbroken that you felt a need to cover yourself in effluent? Erling Kagge, a Norwegian explorer, has. In his latest book, "Walking: One Step at a Time" (translated by Becky Crook), he describes how the sewer he was navigating once became so small that he was forced to shuffle on his stomach, his nose skimming a river of muck. He emerges into daylight head to toe in human waste, yet feeling better for his jaunt.

In his previous book, "Silence: In the Age of Noise", Mr Kagge emphasised the quiet of subterranean New York. In "Walking" he revisits the urban underworld to reflect on the therapeutic effects of exploration. The first person to complete the "Three Poles Challenge"—ie, reaching both poles and the summit of Mount Everest—on foot, Mr Kagge reminisces about how far he has gone to escape. In those sewers he took a break from his crumbling marriage and dodged arrest for trespassing. He lives out his notion that pain can be "beneficial and pleasurable"; his credo is that shortcuts make any endeavour "superficial" and pointless.

Initially his book risks becoming a didactic screed about the dangers of modern technology, as the author laments the way cars, trains, buses and gawking at a smartphone speed life up, leaving little to be savoured. Yet in the end it is much more subtle than a typical self-help tome. He does not expect his readers to visit the meanest streets of Los Angeles, as he has done, or become so hungry that they crouch in the snow to retrieve a single lost raisin, as he did in Antarctica. Instead he uses his acquaintance with extreme environments to reflect on the mental and physical benefits of walking.

"He who walks lives longer," he writes, but that is "only half the truth". The other half is that the act of walking also slows down time, and forces you to consider your surroundings. "The mountain up ahead, which slowly changes as you draw closer, feels like an intimate friend by the time you've arrived." Walking, in other words, prolongs the experience of life, as well as life itself.

Cli-fi

The tallest story

Can the novel handle a subject as cataclysmic as climate change?

THE LITERARY novel has a problem with scale. For centuries it has principally focused on the stuff of everyday life. It doesn't generally concern itself with the cataclysmic or tectonic. Compare Homer's "Odyssey" with James Joyce's "Ulysses": whereas the epic incorporates gods, slaughters and the fate of nations, the novel celebrates the intimate and quotidian.

The literary novel has a problem with time. Novels are one of the ways in which a culture thinks about the challenges it faces, but frequently the form looks to the past to illuminate the present, rather than into the future. The Victorian novel pondered the rapidly industrialising economy and shifting class structures of the age. Yet many of the great books of the period, from "Middlemarch" to "A Tale of Two Cities", employed historical settings. Today's novelists often turn to the two world wars, or even more remote eras, for their subjects.

These tendencies are a handicap in the age of climate change, a crisis which is both current and to come. The Indian novelist Amitav Ghosh recognised this drawback in "The Great Derangement", a collection of essays published in 2016. In a piece ostensibly about environmental catastrophe, Mr Ghosh pondered the cultural role of the novel. Climate change, he argued, seems just too capacious, uncertain and abstract a subject to be addressed by a form with an innate fear of the unknowable and provisional—ie, of the future. And if the novel cannot confront the biggest danger to humanity, can it retain its relevance?

Time is a factor in more ways than one. Particularly since Modernism, which saw Joyce and Virginia Woolf anatomise the minutiae of life, literary time has been circumscribed. Whether it is Mrs Dalloway's day or the longer arc of the *Bildungsroman*, there is generally an inherent limit on the temporal horizons of serious novels: the length of a character's life. Novelistic time is tightly bounded, as well as being sequestered in the past. The leap forward needed to envisage the climate's trajectory requires more elastic parameters.

Not all fiction is hobbled in this way. What Mr Ghosh snobbishly calls the "generic outhouses"—speculative and science fiction—have tried to tackle climate change head-on. These genre boundaries are blurry and contested: J.G. Ballard's "The Drowned World" (1962), a sci-fi novel that was among the first to deal with climate-related fears, has been reassessed and reclassified as the author's reputation evolved. But the literary novel has long defined itself in opposition to other genres, and the future and its risks have been tainted by association. At least, they were until recently.

Not waving but drowning

As the divide between literary and other types of fiction has become increasingly porous, so the literary establishment has begun to recognise the imaginative possibilities of climate change. Cormac McCarthy's "The Road" (2006), in which a father and son traverse an ashen landscape after an unnamed apocalypse, was an early turning point. The book served as a bridge between the fears of one generation, which involved mushroom clouds and mutually assured destruction, and those of the next, which are of melting ice caps and wildfires.

Mr McCarthy wrote "The Road" after becoming a father in his 50s. Gazing over a Texan landscape with his son, he imagined the hills scorched black, depredations the boy would see but he would not. The story can be interpreted as a message from Mr McCarthy to his child, as a metaphor for a universal anxiety about leaving offspring to fend for themselves, and as a dramatisation of a horror that humans have despoiled the Earth. The book draws attention to the fact that novels are in a sense always about the future, because that is when they will be read. It was a breakthrough for writers keen to engage with the climate. Novelists including Ian McEwan and Margaret Atwood have done so.

Now the genre that Mr McCarthy helped galvanise, sometimes known as "cli-fi", is gathering pace. His impulse to tell stories for future generations animates two recent examples. In "The End We Start From", Megan Hunter evokes "An unprecedented flood. London. Uninhabitable. A list of boroughs, like the shipping forecast, their names suddenly as perfect and tender as the names of children." The anonymous narrator shepherds her baby son, Z, through this flooded Britain in search of safety and the boy's father. The narrative is interlaced with passages from mythological sources, closing the circle between the destructive floods of the cli-fi future and the watery origin stories of many religions.

Similarly, Louise Erdrich's "Future Home of the Living God" purports to be written by a woman to her unborn child, preparing it for the world it will inhabit. A thermometer ticks upwards like a primed bomb; the novel ends with a lyrical passage in which the narrator recalls the snows of her youth. "Next winter it rained. The cold was mild and refreshing. But only rain. That was the year we lost winter."

Some dystopias combine the spectre of climate carnage with other fears. John Lanchester's "The Wall" imagines a future in which Britain's coastlines have been replaced by the titular wall, built to hold back both the rising tides and the "Others"—boat-borne hordes seeking refuge. The migrant crisis and Brexit contribute to a bleak vision of paranoid insularity. In Omar El Akkad's "American War", meanwhile, swathes of late-21st-century America are under water. Florida has vanished; a second civil war erupts over fossil-fuel usage.

Literary novelists have begun to appreciate that climate change is not just an urgent subject but a font of drama and plots. All too soon the theme may revert from the territory of science fiction to the realm of old-fashioned realism. ■

The Road to the future