

Books & arts

He also developed an alternative to the EPR challenge that held the promise of translation into a real experiment.

Befuddled by Bohrian vagueness, finding no solace in student textbooks and inspired by Bohm, Irish physicist John Bell pushed back against the Copenhagen interpretation and, in 1964, built on Bohm's version of EPR to develop a now-famous theorem³. The assumption that the entangled particles A and B are locally real leads to predictions that are incompatible with those of quantum mechanics. This was no longer a matter for philosophers alone: this was about real physics.

It took Clauser three attempts to pass his graduate course on advanced quantum mechanics at Columbia University because his brain "kind of refused to do it". He blamed Bohr and Copenhagen, found Bohm and Bell, and in 1972 became the first to perform experimental tests of Bell's theorem with entangled photons².

French physicist Alain Aspect similarly struggled to discern a "physical world behind the mathematics", was perplexed by complementarity ("Bohr is impossible to understand") and found Bell. In 1982, he performed what would become an iconic test of Bell's theorem⁴, changing the settings of the instruments used to measure the properties of pairs of entangled photons while the particles were mid-flight. This prevented the photons from somehow conspiring to correlate themselves through messages or influences passed between them, because the nature of the measurements to be made on them was not set until they were already too far apart. All these tests settled in favour of quantum mechanics and non-locality.

Although the wider physics community still considered testing quantum mechanics to be a fringe science and mostly a waste of time, exposing a hitherto unsuspected phenomenon – quantum entanglement and non-locality – was not. Aspect's cause was aided by US physicist Richard Feynman, who in 1981 had published his own version of Bell's theorem⁵ and had speculated on the possibility of building a quantum computer. In 1984, Charles Bennett at IBM and Giles Brassard at the University of Montreal in Canada proposed entanglement as the basis for an innovative system of quantum cryptography⁶.

It is tempting to think that these developments finally helped to bring work on quantum foundations into mainstream physics, making it respectable. Not so. According to Austrian physicist Anton Zeilinger, who has helped to found the science of quantum information and its promise of a quantum technology, even those working in quantum information consider foundations to be "not the right thing". "We don't understand the reason why. Must be psychological reasons, something like that, something very deep," Zeilinger says.

The lack of any kind of physical mechanism to explain how entanglement works does not prevent the pragmatic physicist from getting to the numbers.

Similarly, by awarding the 2022 Nobel Prize in Physics to Clauser, Aspect and Zeilinger, the Nobels as an institution have not necessarily become friendly to foundational research. Commenting on the award, the chair of the Nobel Committee for Physics, Anders Irbäck, said: "It has become increasingly clear that a new kind of quantum technology is emerging. We can see that the laureates' work with entangled states is of great importance, even beyond the fundamental questions about the interpretation of quantum mechanics." Or, rather, their work is of great importance because of the efforts of those few dissidents, such as Bohm and Bell, who were prepared to resist the orthodoxy of mainstream physics, which they interpreted as the enduring myth

of the Copenhagen interpretation.

The lesson from Bohr–Einstein and the riddle of entanglement is this. Even if we are prepared to acknowledge the myth, we still need to exercise care. Heilbron warned against wanton slaying: "The myth you slay today may contain a truth you need tomorrow."

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The pill: a revolution that started with troubling trials

Bold play remembers Puerto Rican women involved in tests of the first oral contraceptive. By Mariana Lenharo

It's the 1950s and two US scientists are looking for somewhere to test the first birth-control pill. Where better than Puerto Rico? The territory had an established network of family-planning clinics, and the use of contraception had been legal there since 1937. That wasn't the case in much of the United States, including Massachusetts, where biologist Gregory Pincus and obstetrician-gynaecologist John Rock were developing the oral contraceptive.

Puerto Rican women were interested in a pill that could give them more control over their reproductive lives. But as they lined up outside a clinic in the outskirts of San Juan to receive the medication, many were unaware that it was an experimental drug and they were part of a clinical trial. When some of them started reporting debilitating side effects, these were dismissed as psychosomatic.

The play *Las Borinqueñas*, whose title means 'the Puerto Rican women', revisits the complicated history of the world's first oral contraceptive. Mixing the excitement of scientific breakthrough with the shock of flawed research ethics and shadows of colonialism and exploitation, it puts the spotlight on the women who, after playing a key part in the pill's development, were quickly forgotten.

Las Borinqueñas

Directed by Rebecca Aparicio
Ensemble Studio Theatre, New York City
3 April – 5 May 2024

It's a long-overdue tribute and, most importantly, a reminder to remain vigilant against abuse and disrespect in studies with human participants. In a world where the fight for access to birth control is ongoing, it is bold and commendable to recognize that this significant advance was built on ethically problematic studies that harmed some of the very women they aimed to serve and empower.

Written by Nelson Diaz-Marcano, a Puerto Rican theatre-maker based in New York City, the show was developed by the Ensemble Studio Theatre in New York and the Alfred P. Sloan Foundation, a research funder based in the city. It had its world premiere on 3 April and is on until 5 May at the Ensemble Studio Theatre.

Taking control

The play follows the intertwined lives of five women – Chavela, Yolanda, Fernanda, Maria and Rosa – as they cross paths with the researchers testing the pill. As the audience witnesses their love stories, aspirations, struggles and loyal friendships, the protagonists



Las Borinqueñas explores how women sought control of their reproductive lives in the 1950s.

open a window on the lives of hundreds of Puerto Rican women who enrolled in the tests, and how the experience changed them.

Each character is affected in a different way. Chavela sees the trial as chance to slow down the growth of her family while maintaining a passionate marriage. Yolanda envisions it as the lifeline that might save other women from the fate of her sister, Fernanda, who dies as a result of an illegal abortion. For Maria, it's about avoiding pregnancy to advance her dream of becoming a writer – and about honouring Fernanda, her soulmate, with whom she could never openly have a relationship because of societal norms. But the hope brought on by the pill slowly fades when the women start feeling unwell.

Rosa, who was suspicious of the pill from the start, urges the others to stop taking it, while boasting about the benefits of the sterilization that she underwent after giving birth. The doctors who suggested the procedure, however, never told her it was irreversible. The heartbreaking scene when she learns she will never be able to have another baby signals that the clinical trial wasn't the first instance of medical abuse these women endured. By 1953, a eugenics-based programme in Puerto Rico had led to the sterilization of nearly one-fifth of women on the island to address concerns about 'surplus population'.

From rabbits to women

The birth-control pill was the result of the encounter of Pincus and Rock, who were both studying the effects of synthetic progesterone, but in different contexts. Pincus was looking into the anti-ovulatory effect of the hormone in rabbits, and Rock was exploring it as a means to treat his patients' infertility. The play

focuses on Pincus, portrayed as an ambitious scientist determined to carve his name into history by creating a revolutionary product.

When someone becomes pregnant, their progesterone levels rise, signalling to the body to shut down the ovaries and not release eggs. Whereas Pincus wanted to mimic this for the purpose of contraception, Rock hoped that a pause in ovulation would allow his patients' reproductive systems to reset, increasing their chances of pregnancy after the treatment.

The scientists came together to test the pill in humans. The play briefly refers to a couple of small trials done in the United States, but to get the pill approved, it had to be tested on a larger scale. Pincus sets his sights on Puerto Rico and

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seeks to partner with Edris Rice-Wray, who was then the medical director of the Family Planning Association of Puerto Rico.

Rice-Wray expresses her concerns about negative side effects that had been observed in previous tests, but is convinced to join the project by Pincus's wife, who highlights the potentially revolutionary implications of the pill for women around the world.

Rice-Wray is portrayed as a responsible public-health official who is nonetheless persuaded to push the boundaries of ethics for the greater good. She launches the programme with fanfare in 1956 and, at the suggestion of Pincus, does not mention the potential side effects to participants, most of whom are poor women

with little access to health care. Her discomfort with the omission increases as she hears that the trial is taking a toll on participants.

In one scene, Chavela is taking laundry from the line when she is struck by dizziness and nausea. Her sister Rosa warns her that the pill is to blame, but she prefers to continue taking it rather than to risk becoming pregnant again. Rice-Wray reports those concerns to Pincus, who minimizes them as minor inconveniences compared with the wider benefits of the drug. Because of his disregard for the Puerto Rican study participants, the real-life Pincus was later accused of colonialism and exploitation of women of colour.

The protagonists eventually stop taking the pill and don't experience long-term consequences. But the play mentions that three Puerto Rican women died during the trial, and that their deaths were never investigated.

Trial and error

In reality, of around 800 women who enrolled in the study, only 130 took the pill for a year or more, most dropping out because of the side effects. To make the results look more impressive, Pincus described them by saying that no pregnancy had been registered “in the 1,279 menstrual cycles” during which the treatment had been followed. In the play, his character brushes off the accusation of data embellishment. For him, it was simply a matter of using a different metric.

The pill, branded Enovid, went on to be approved by the US Food and Drug Administration as a contraceptive in 1960. The trial participants didn't have access to the product once it reached the market: the price was prohibitive for the Puerto Rican working class.

More than six decades later, the contraceptive pills available are much safer. But access is still an issue. In the United States, until last year, people still needed a prescription to buy oral contraceptives – a significant barrier for those without health insurance.

Las Borinqueñas concludes with the women refusing to be defined by the experience of being exploited by scientists and having their right to decide about their own reproductive lives stripped away. Rosa publicly denounces the pill's side effects and the irreversibility of sterilization on a radio show; she also conveys her resilience and hope for the future. The women will continue to take care of their families, to work and to pursue their dreams. They celebrate life and laugh at adversity.

Some would argue that their suffering was a small price to pay for the wider impacts of pill. But by giving names to the study participants and telling their stories, *Las Borinqueñas* serves as a powerful reminder that such disregard and injustice was never acceptable.

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