Mathematical Lives

DAVID BLACKWELL
AND THE DEADLIEST DUEL

Robert Black

Royal Fireworks Press
Unionville, New York

Also by Robert Black,
published by Royal Fireworks Press:
The Mathematical Lives series
The Mathematical Nights series
Liberty Girl
Unswept Graves
The Eyes of the Enemy

Royal Fireworks Press
P.O. Box 399
41 First Avenue
Unionville, NY 10988-0399
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website: rfwp.com

ISBN: 978-0-88092-807-6

Publisher: Dr. T.M. Kemnitz
Editor: Jennifer Ault
Book Designer: Kerri Ann Ruhl
Cover Illustrator & Designer: Christopher Tice

Printed and bound in Unionville, New York, on acid-free paper
using vegetable-based inks at the Royal Fireworks facility. 17ja22

local 363

Prologue

The Way Machines Learn

Have you ever seen the 1980s movie *War Games*? In it, the teenage hero unwittingly hacks into a powerful supercomputer, called the War Operation Plan Response, or WOPR (pronounced "whopper"), housed in the U.S. military's nuclear command post. Built to calculate the ultimate nuclear war strategy, the WOPR was programmed to learn by playing games like tic-tac-toe and chess. Without realizing what he's doing, the hero convinces the WOPR that an actual nuclear attack is imminent, and then he must stop it before it launches missiles for real.

Luckily for us, the story is fiction. No teenage hacker has ever put us on the brink of nuclear war (or at least, none whom we know about). But the movie did have an element of truth behind it. From the early days of the Cold War, the United States really did try to develop combat strategies using a new field of mathematics called *game theory*. In Southern California, the RAND Corporation, a nonprofit company backed by the U.S. Air Force, employed dozens of mathematicians, some full time but many for short-term projects, to study game theory and find ways of applying it to warfare.

One of those mathematicians was a visiting professor from Howard University, the country's most prestigious historically Black college—that is, a college established for African-American students before the Civil Rights laws of the 1960s. David Blackwell was only the seventh African-American to earn a Ph.D. in mathematics, and in 1947 he had become the chairman of Howard's math department. For several years, he spent his summers at RAND, where he became an expert on analyzing duels—contests in which two opponents face each other and need to choose the best moment to fire their guns. Beginning with a basic duel, he went on to study cases in which the guns were silent, cases in which the participants had methods of spying, and so on, until he developed a general theory for "games of timing."

The Cold War years were also when the electronic computer was developed, and as computers became more powerful, mathematicians began using them to analyze games that were much more complicated. As computers became faster, they could use game theory to analyze an entire range of possibilities and find solutions quickly. At the same time, computer scientists were discovering that the techniques of game theory could help them in their efforts to invent artificial intelligence.

As for Blackwell, in 1956 he joined the newly-formed statistics department at the University of California at Berkeley, where he spent the rest of his career. His work took him into the field of statistical decision-making and then into another new field called *information theory*. Both areas of study have played important roles in the development of computer technology. Blackwell was never a computer scientist himself, but his mathematical contributions have been making computers smarter and faster for decades.

And yet many of these contributions came during a time when large parts of American society wanted nothing to do with Blackwell because of his race. He claimed that he was always too focused on mathematics to pay much attention to racial issues, but several turning points in his life and career were the result of discrimination against him.

Even so, Blackwell's perseverance and his passion for math problems that he saw as interesting and beautiful produced a long and fruitful career—one in which he not only developed new mathematics himself, but he also taught many talented students who went on to make their own discoveries.

And his story began in an iconic American place: a Midwestern railroad town.

Chapter One

Mr. Huck's Mathematics Club

In southern Illinois, in the southwest corner of Clinton County, where it meets Jefferson, Marion, and Washington counties, you'll find the town of Centralia. It's at the crossroads of the two original lines of the Illinois Central Railroad, the first railroad chartered under a United States land grant and the railroad that for much of the 1850s retained a lawyer named Abraham Lincoln. Centralia was founded in 1853 as a hub to support the Illinois Central trains and tracks.

In the fall of 1911, a group of affiliated labor unions went on strike against the Illinois Central. Rather than negotiate, the railroad brought in replacement workers to fill the vacated jobs—but not just any workers. By that time, the Illinois Central had expanded south, through Mississippi and all the way to New Orleans and to Mobile, Alabama, and so the company recruited African-Americans from those areas to move north and replace the strikers, who were almost all white.

One of those replacement workers was Grover Blackwell, originally from Weakley County in northwest Tennessee. His formal education had only reached the fourth grade, but by the time he was in his late teens, he had enough talent and experience for the railroad to bring him to Centralia as a hostler, one of the men who took the locomotive engines to and from the roundhouse where they were kept. When the strike was finally broken and the original workers returned, the railroad kept some of the replacements, splitting up the workload into jobs for white workers and jobs for Black workers, and hostler positions were among the ones assigned to Black workers. Grover was in Centralia to stay.

One Sunday after church, Grover met a young woman named Mabel Johnson, the daughter of a local grocery store owner. Courtship and marriage followed, and the couple settled into a two-story house surrounded by Mabel's relatives. In fact, around town the area was nicknamed "Johnson territory." The couple was far from wealthy, but they earned a living, with Grover working seven days a week and Mabel managing a pair of rental houses on the family property. The two-story house would remain theirs for the rest of their lives.

David Blackwell was born in that house on April 24, 1919. In the years that followed, he would gain two brothers, Johnson Wesley, or "Skeet," born in 1926, and Joseph, born in 1928. A sister, Elizabeth, or "Betty Lou," completed the family in 1941. By that time, David had almost finished school, an accelerated journey that took some unexpected turns.

Just as Centralia was at the center of the railroad, it was also on the middle ground when it came to school integration. In towns to the north, Black and white children went to school together, but in towns to the south, they went to separate schools, with the schools for Black students typically receiving less money and upkeep and having fewer teachers. Centralia had five elementary schools, but only one part of town had separate schools for Black and white children. The Blackwells lived nearest one of the three integrated schools, and that was where they sent David. It may have been integrated in theory, but in practice it was mostly white. Here is one of David's class photos, from about 1930. David is on the left end of the front row.

David later recalled that he was rarely teased or harassed because of his race, but he *was* teased because of his small size. He advanced through school quickly, spending only about half a year in each of the first four grades so that by the end of elementary school, he was two years younger than his classmates, and much smaller.

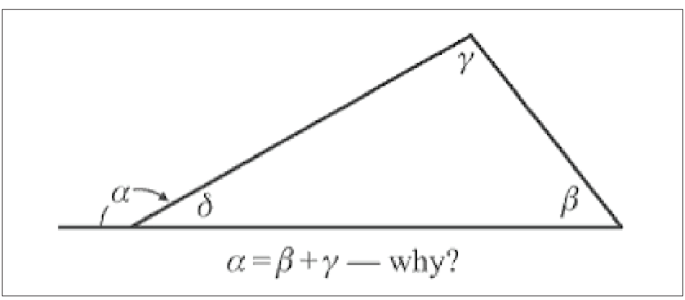
David's reading ability was the driving force behind his rapid progress. Once he could read at the level appropriate for a grade, he was moved into that grade. That ability had gotten an early start in the family grocery store, where he had read the seed packages that were on sale. If the package had a picture of tomatoes on it, for example, he reasoned that the letters *t-o-m-a-t-o* on the label spelled *tomato*. As his reading skills developed, he enjoyed reading fantasy and adventure stories, especially the Tarzan books of Edgar Rice Burroughs.

Outside of school, David's life, like the lives of most people in Centralia, revolved around the railroad. His friends, who were mostly African-American, were the children of his father's fellow railroad workers. David was never interested in a railroad job himself (unlike Skeet, who grew up to have his own career with the Illinois Central), but he did enjoy it when Grover took him for rides in a locomotive and let him pull the throttle a few times.

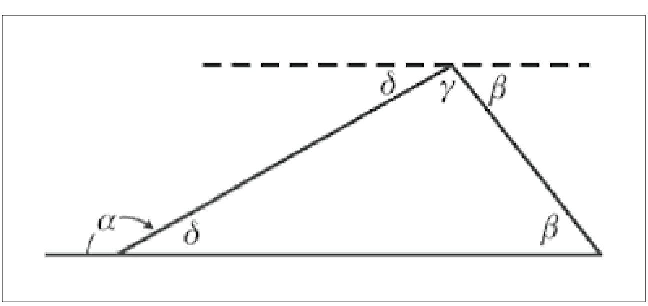
It wasn't until high school that David took an interest in math. Before then, he simply hadn't been around anyone with enough mathematical knowledge and experience to show him its possibilities. The most educated member of his family had been his Grandfather Johnson, who had passed away before David could know him. His uncle could add three columns of numbers without having to write them down, which was useful for running the family store but not for giving advice on math as a subject in general. Fortunately, the teachers at Centralia High School (where the boys' athletic teams are called the "Orphans" and the girls' teams are called the "Annies," even today) could give him the guidance he needed.

The first class that awakened David's interest was geometry, taught by a woman named Caroline Luther, who also taught German. David later recalled that geometry was the first class—the only class until he reached college, in fact—that showed him that math could be "beautiful and full of ideas."

One technique that fascinated him was the use of a "helping line"—the addition of a single line that could make a difficult problem look obvious. A classic example is the proof that the exterior angle of a triangle is the sum of the remote interior angles. This theorem leads directly to the conclusion that the angles of a triangle add up to 180 degrees, the thirty-second proposition in Euclid's *Elements*.

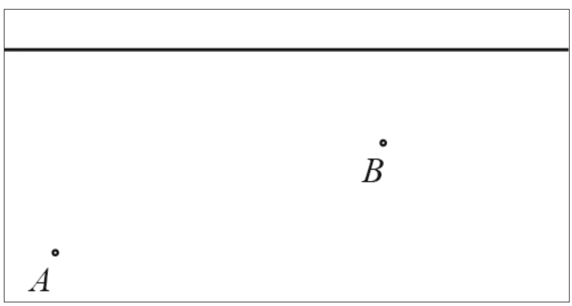


All you have to do is draw a "helping line" parallel to the triangle's base and passing through the vertex of angle γ, and the answer becomes clear.



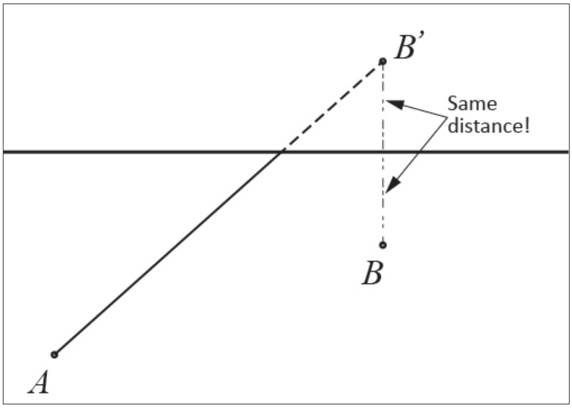
Because the lines are parallel, we know that the angles on either side of γ are equal to δ and β. (That's Euclid's twenty-eighth proposition, for "alternating angles.") And because δ combines with α to form one line, and it combines with γ and β to form another line, we know that α must equal γ + β. Lastly, since a straight line is considered to be an "angle" of 180 degrees, we know that the three angles of the triangle add up to 180 degrees—all from drawing one line.

Another problem that looks difficult but becomes easy with one small addition involves two points on the same side of a line.

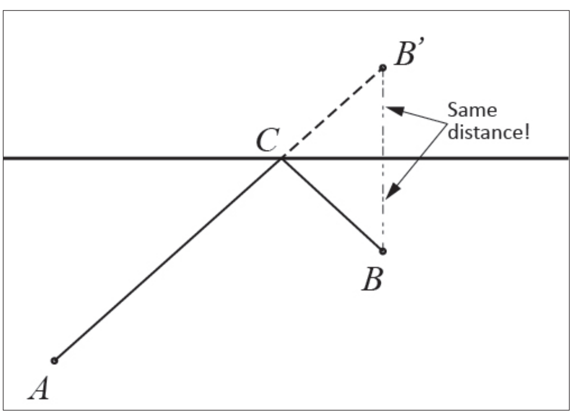


Imagine, for example, that the line represents a river, and you must go from point *A* to the river and then to point *B*. (Maybe you've got an empty bucket, and your friends at point *B* need water.) Where should you go along the riverbank to travel the shortest distance?

Once again, a problem that looks hard is actually easy. All you need to do is add another point, *B'*, across the river from *B*, like a mirror image.



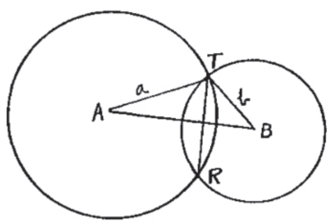
The shortest distance between two points is a straight line, so it's easy to find the shortest path from *A* to *B'*. If you go to the point where that line crosses the river—let's call it point *C*—it's possible to show that the distance from *C* to *B* is the same as the distance from *C* to *B'*. In other words, point *C* is where you should go to travel the shortest distance from *A* to the river to *B*.



The teacher who had the most influence on David was a man named Raymond Huck, who taught math and also sponsored the school math club. In many of the club meetings, he brought in the latest copy of a magazine called *School Science and Mathematics*, which included a section of challenging problems. Each time a new issue came out, David and the other club members chose problems and tried to solve them. When they came up with an interesting or novel solution, Huck wrote it up and sent it to the magazine. Twice David had his name listed among the people sending in correct answers, and once his complete solution was published. True to his high school preference, it was a geometry problem, although one needing a bit more effort than simply using a helping line or a mirror image.

1415. *Proposed by Dewey C. Duncan, Compton, Calif.*

Find the length of the common chord of two intersecting circles with radii a and b, if the segment of the line of centers common to the two circles is $2c$ in length.



Solution by David Blackwell, University of Illinois.

The sides of triangle ATB are a, b, $a+b-2c$. Then when $s=a+b-c$.

$$\text{Area triangle } ATB = \sqrt{s(s-a)(s-b)(s-a-b+2c)}$$
$$= \sqrt{(a+b-c)(b-c)(a-c)c}$$

$$\text{Also area triangle } ATB = \frac{TR}{4}(a+b-2c)$$

$$\text{Hence } TR = \frac{4\sqrt{(a+b-c)(b-c)(a-c)c}}{a+b-2c}$$

By the spring of 1935, David was sixteen years old and graduating from high school. There was never any doubt what he would do next: he would go to college. His parents, despite not having much formal schooling themselves, wanted all of their children to go to college, and the parents of his friends wanted the same for them. One of David's English teachers encouraged him to attend her alma mater, DePauw University in Indiana, but he already knew where he wanted to go. The University of Illinois automatically accepted any high school graduate from the state, and its Urbana-Champaign campus was only about 100 miles from Centralia. Because his father worked for the railroad, he could ride the train for free. Visiting his family would be a three-hour trip that he could take as often as he liked. It was an easy choice.

His choice of what to study in college was a different matter. When he left home, David didn't plan on becoming a mathematician. Instead, he had decided that he would become an elementary school teacher. The country was still in the grip of the Great Depression, and secure jobs were scarce, especially for African-Americans. A friend of Grover's who was on the school board in Pulaski County, at the southern tip of Illinois, had promised David a teaching job after he earned his degree. It was a sensible plan.

And so when fall came, David left on his own, riding the train and then walking the mile and a half from the station to campus. He was on his way to inquire about housing when an older African-American student saw him and came over to meet him, inviting him to join one of the university's Black fraternities and live at their house. It was a promising start to his college career.

By the end of that career, his life would be heading in a completely different direction.