

DIAMOND WISDOM

Tom Arendshorst, September 14, 2017

In the spring of 1953 my parents moved my brothers and me to Scott Air Force Base, twenty-five miles east of St. Louis, Missouri.

Imagine, if you will, a small boy lying on his bedsheet in the steamy swelter of an August evening next to a simple pine desk on which rest his glasses and a radio tuned to the St. Louis Cardinals' game on KMOX, listening to voice of a young Harry Caray broadcast the ball game, falling in love with the Cardinals and, over time, with the drama and arcana of baseball in general. That summer Stan “the Man” Musial, one of the very greatest baseball players ever, hit .337, clouted 30 home runs, drove in 113 runs, and played every game for the Cardinals. My seventh birthday present was a family outing to St. Louis for supper at Stan’s restaurant, where we met The Man; he took my older brother Bill and me into his office and signed photos for us. I still have mine: “To Tommy, Best Wishes, Stan Musial.”

How many of us grew up as youthful baseball fans, and remember Al Kaline, Hank Aaron, Willie Mays, Sandy Koufax, Bob Gibson, George Brett, Alan Trammell and Lou Whittaker, Ozzie Smith, Cal Ripken—or even, Vern, Charlie Gehringer and Mickey Cochrane? *[raise hands]* This talk is for you. But it’s also for those of you whose lives have not been brightened by baseball, because the lessons of baseball apply to all we do. ☆

**** PP 2 **** Baseball wisdom—the principles that guide baseball strategy and tactics—evolved from perceived experience and cultural folklore, the same way all cultural wisdom evolves. Prior to 1977 baseball wisdom was like medieval wisdom about the natural world before Galileo and Copernicus: its framework was a set of unquestioned, religious precepts, an orthodoxy based on benighted perceptions.

In 1953 it was believed—*known*—that the best hitters had the highest batting averages, the most valuable hitters were those who drove in the most runs, the truest measure of pitching excellence was the number of games a pitcher won, and bases on balls were the simply the result of a pitcher’s poor control. In 1952 the Most Valuable Player Award in the National League was won not by Musial or peak-of-career Jackie Robinson or 28-game-winner Robin Roberts, but by Hank Sauer, a slow-footed, poor-fielding 37-year-old Cub left fielder who led the National League in RBIs but was, in retrospect, not close to the most valuable player in the league. Baseball scouts evaluated prospects by how they looked, and veteran big-league players were assumed to possess some essential quality that made them superior to young, “unproven” players. Prior to the 1950s, baseball wisdom held that African-American players were inherently less reliable, less coachable, less durable, less disciplined, less gritty, less courageous, less diligent.

**** PP 3 **** In 1977 Bill James began publishing his yearly Baseball Abstracts, and since then baseball wisdom has doffed its hidebound flannels and has acquired a new wardrobe of revolutionary information, conclusions, principles, and strategies. The vehicle of all this change has been science, and, just as Galileo broke the stranglehold of traditional wisdom's ignorance about the natural world, it has been Bill James who has driven the development of baseball's scientific new wisdom. In the world of baseball, the work of Bill James has been analogous to the challenges Galileo presented to the myth-based religious orthodoxy of the sixteenth century.

Bill James was born in 1949 in Kansas, earned degrees in English and economics at the University of Kansas, and was working as a security guard at the Stokely Van Camp pork and beans factory in 1977 when he self-published his first *Bill James Baseball Abstract*, **** PP 4 **** a stapled-together paperback based on his own painstaking analysis of big-league game statistics. Unlike most writers, his pieces did not romanticize games or pass along insights gleaned from interviews with players. A typical James piece posed a question (*e.g.*, "Since the purpose of fielder is not to avoid errors but is to turn batted balls into outs, can we find ways to measure which fielders accomplish this task most effectively?"), and then presented data and analysis written in a lively, insightful, and witty style that offered an answer. James avers that he is not a mathematician, but his studies and writings have been full of baseball stats and calculations.

James wrote another *Baseball Abstract* each year until 1989, and has since continued writing hard-cover books about baseball history, and has been an advisor to the Boston Red Sox since 2003. The contributions of Bill James to baseball wisdom underlie the story of the book and movie, *Moneyball*, and have guided the best baseball teams of recent years as they have constructed their winning teams.

While I may be a baseball nut, what I enjoy most in James's books is his writing style, an irreverent and unpredictable mix of baseball fan stuff with humor, disrespect for wooden-headed stupidity, and philosophical insight. I have enjoyed watching him lead the curious, questioning assault of rational science against the follies of unfounded wisdom in the world of baseball.

One of my favorite examples of Bill James's writing comes from his address to the Kansas University Statistics Department, which he titled "Battling Expertise with the Power of Ignorance," in which he described his approach to his questions about baseball. "I have worked my entire life for the advancement of knowledge," he said, "trying to increase respect for reason and respect of research in the world of sports. We are all, in my view, condemned to float endlessly in a vast sea of unanswered questions –a Sea of Ignorance, if you will. . . Since the world is billions and billions of times more complicated than the human mind, individual intelligence is almost entirely irrelevant to understanding

the world. What is critical to understanding is humility and cooperation. What is critical to gaining more understanding of the world is to learn to accept and appreciate the vastness of our ignorance, and to understand that one can only survive in a sea of ignorance by working with others to make our small lifeboat a little bit stronger. Only by embracing the fact of our limitless ignorance can one position oneself to increase the store of knowledge.”

**** PP 5 **** Bill James’s studies have revolutionized baseball strategy at all levels, from developing players to constructing teams and lineups to managing in-game decisions. James says his approach has been one of curiosity, wondering if some expert contention is true and trying to ask the right question to test that expert opinion. Here are some examples of Bill James’s testing of established baseball “wisdom,” and of the refinements of baseball wisdom that have resulted from his humble curiosity.

In the beginnings of his work James questioned the way baseball experts judged talent and assembled their offenses, which generally featured power hitters who were considered “clutch hitters,” “RBI men,” guys with high batting averages, and speedy base-stealers—all of them experienced, “veteran” players. “What is the team trying to do?” he wondered. “Win games,” was his answer. “How do you win games?”—“by scoring runs.” Indeed, the obvious, only purpose for every batter is to help his team score runs. James discovered that the number of runs a baseball team scores, and the number of runs it gives up, are related to the team’s probability of winning games in an extremely predictable way, and he called his discovery “The Pythagorean Relationship of Runs to Wins”: $\text{Wins} / \text{Losses} = (\text{Runs Scored})^2 / (\text{Opponents' Runs Scored})^2$. **PP** No one in baseball history had ever figured that out before. Now the news coverage of league standings in every sport include each team’s runs or points scored and opponents’ runs or points scored.

PP Well, since scoring runs and not letting the other team score runs really is the goal of play, James next used regression analysis, plugging in everything from singles and doubles to stolen bases, times caught stealing, hitting into double plays, and sacrifice bunts, and derived his Runs Created formula, figuring out how to measure each batter’s contribution to scoring runs – creating an exacting tool by which every batter’s performance in creating runs for his team could be compared to any other player. He developed the Runs Created formula.

His research included some surprises for old-school baseball experts. On-Base Percentage turns out to be the strongest single predictor of offensive efficiency—more important than batting average, home runs, RBIs, clutch hitting, any other single measure. **PP** On-Base percentage is essentially the ability to get hits (singles, doubles, triples, home runs) plus the ability to draw walks—and it turned out

that *batters* had more to do with bases on balls than pitchers' wildness. The best leadoff batter, then, should be not a speedy base-stealer but a guy who can get on base—draw walks and get hits. And a man who bats .300 but rarely walks hits what James calls an “empty” .300, worth much less to his team than a guy who hits .250 but draws a base on balls 12% of his plate appearances. James studied and found that a team's chances of scoring in an inning are doubled if the leadoff batter gets on base. In the race between batters to move runners around to home and the opposing pitcher and defense to get three outs, every out is crucial. “Not making outs” isn't flashy, but it's the cornerstone of scoring runs, the On-Base-Percentage.

Today, forty years later, there are still a few managers who still haven't accepted this crucial wisdom, and who insist on batting base stealers with low on-base-averages in front of their best hitters, and their teams have a hard time scoring runs. Detroit manager Brad Ausmus did this two years ago with Rajai Davis. But the successful managers—Joe Maddon, Buck Showalter, Joe Girardi, Bruce Bochy—always have high on-base men at the top of their batting orders, and hitters who draw a lot of walks (Joey Votto, Matt Carpenter) are valued for their ability to work pitchers, get on base, and score runs.

PP A major spinoff of this early part of James's research has been the understanding that, if a base stealer isn't successful 70-75% of the time he's actually damaging his team's chances of scoring runs. That is, base stealing is only profitable if it's successful 80% of the time. As this knowledge has gained acceptance, stolen bases have become more rare. As James has proven, the cost of an out—you only get three—is much, much greater than the gain of one base from first to second. This calculation does shift a little when you only need a single run—when tied or one run behind in the ninth inning—but a failed base stealing event in a terrible inning-killer, and it's Bill James who has pushed this understanding into Baseball Wisdom.

The second-strongest correlate to scoring runs, after On-Base-Percentage, is Slugging Percentage—bases a batter earns per at-bat, where a single is one, a double is two, and a home run is four bases. Slugging Percentage is the combination of Batting Average and Power. The greatest hitters have high Slugging Percentages: Babe Ruth, Ted Williams, Stan Musial, Hank Aaron, Willie Mays, George Brett, Albert Pujols, Miguel Cabrera.

PP For generations of baseball experts Runs Batted In, RBIs, were perhaps the most revered of all offensive statistics. RBIs were often viewed as the single best measure of a player's contribution to his team. James's analysis of what scores runs upset established Baseball Wisdom again by finding that how many runs a guy bats in is a poor predictor of his actual creation of runs for his team. Old baseball wisdom understood that the number of runs a player scored depended on the batters who came

up behind him, but somehow missed that a star's runs batted in are fully as dependent on the players who came up in front of him. James proved that RBIs are largely the product of whom a hitter bats behind—the guys who precede him in the batting order. You can only drive in runs if the guys before you have successfully gotten on base and moved into scoring position. In 1985 Cardinal Tommy Herr drove in 110 runs while hitting only 8 homers—because he followed Vince Coleman, Ozzie Smith, and Willie McGee in the batting order, men who were always on base and ran like hell.

Further, James ran multiple studies and has never been able to find evidence that there are any major league hitters who hit better in “clutch” situations than they do the rest of the time. There is no hitter in all of baseball who hits predictably better in pivotal situations than he usually does. Like Bigfoot, the Clutch Hitter turns out to be an animal a lot of people insist is there, but there's no evidence to back up that faith. The great mouth, Reggie Jackson, claimed he was “Mr. October,” but if he was, it was only the result of a small statistical sample size or Jackson's famous propensity to not give a shit the rest of the time.

The myths of “The RBI Man” and “The Clutch Hitter” are dying slow, hard deaths. Some broadcasters and many past players find it difficult to believe that their “Insider” understanding exists only the way Bigfoot exists.

PP Every year, when a team gains a superstar player via trade or free agency, baseball Experts gush that “Getting Bashing Blake will be worth 10-20 more wins for the Muskrats next year.” James wondered if this could possibly be true, so he studied what has happened, ran predictive analyses based on the relationship of runs created to team wins. What he found is that the difference between a superstar and the player he would replace is 3 to 4 wins over the 162-game course of a season. James's unlikely proof highlights that baseball is, much more than are basketball and even football, a team game; even Mike Trout only gets to bat four or five times in a game. This realization, combined with James's research proving the high value of developing blue-chip minor leaguers and draft picks, has helped some general managers, like the As Billy Bean and the Cubs' Theo Epstein, deal away their aging stars in exchange for young talent that would turn their teams into powerhouses in the coming years.

**** PP 6 **** One of James's favorite contributions to New Baseball Wisdom has been the notion that baseball talent is a pyramid. **PP** The ability to play baseball, says James, is distributed among the general population in a Bell curve—but the players we see, Minor Leaguers and Major Leaguers, **PP** are those at the far right-hand end of the curve. The greatest players are in the tiny pointed end of that triangle—**PP** which, if you turn it on its side and balance it, is a two-dimensional view of a pyramid. **PP**

PP Baseball Wisdom had long held that major league veterans were distinctly superior to all the “unproven” players in the minor leagues –that there existed **PP** a real gap of talent between those men who were in Major League ball and all the players in the Minor Leagues. Major League teams were reluctant to entrust a regular job to minor leaguers. But James wondered 1) if minor leaguers’ performances really offered such untrustworthy information and 2) how, in his conception of the pyramid of baseball talent at the right-hand end of the Bell curve, there could be a break, a discontinuity, in that distribution of talent. Logic insisted to James that the best young minor league players had to be at least as good as the lower ranks of major leaguers, whom James termed “replacement-level” major leaguers. So Bill studied the relationship of players’ minor league stats to their later major league performances, and found **PP** that minor league statistics are just as predictive of subsequent major league performance as are the stats of established major leaguers. There is no gap. The majors are a tougher environment, but tougher to a predictable degree. Over the past two decades the baseball establishment has gradually grasped and used this revelation, bringing their best young players up to the majors earlier and wasting less of those players’ careers in minor league purgatory. Where the teams—and especially their benches— of my youth in the 1950s were populated with mediocre, middle-aged white guys like Peanuts Lowery and Dusty Rhodes, the major leagues today are full of great young kids. Gone are Peanuts and Dusty, and stepping into the batter’s box is Jose Martinez.

**** PP 7 **** **PP** Even though every fan and pundit knew that home runs were easy to hit over the Green Monster in Boston’s Fenway park and that it took a monster to hit one out of the old St. Louis Busch Stadium or the old Houston Astrodome, Baseball Experts still expected a hitter –let’s say the Red Sox’ Freddie Lynn—to have the same batting stats if he were traded from Boston to Oakland, where hitters’ numbers die, a hitter’s haven. Baseball Experts would be surprised when a pitcher traded to St. Louis, where he’d pitch half of his games in a pitcher’s paradise, would suddenly lower his Earned Run Average by 40%. Bill James’s studies led the New Baseball Wisdom that recognizes the gigantic leverage of what are now called “Park Effects” on baseball players’ statistics. We know now that when a Colorado Rocky—Troy Tulowitzki or Todd Helton—hits .330 and belts 35 home runs, his batting average when he plays in everybody else’s stadiums is 100 points lower than when he plays at home, and that he hits two-thirds of his homers at home –he’s not nearly as great as his Colorado stats make him appear. And we know that a pitcher moving from San Francisco to the Yankees is going to get a lot more home runs hammered off him in easy-homer-Yankee Stadium.

We’ve heard ever since Howard Cosell that Momentum is paramount during games, and even through seasons. When you’re going well, you become a juggernaut. If momentum shifts against you,

you call a timeout or instigate a rhubarb or, if you're a tennis player, take a 20-minute "medical" time out. James wondered if momentum is a real thing in baseball, so he performed a variety of studies. What he found is—you guessed it—that momentum does not exist. A batter who's been hot or cold, over any period of time, will most likely perform at his long-term norm in coming at-bats and games. A team that's hot—which has deviated from its usual pattern of wins and losses—is most likely not to stay hot in its next series of games. Same thing for being cold: it's not predictive of more cold. James wrote, "The illusion of momentum will, in time, I think, be overpowered by its own absurdities. . . . As a small child, I thought that the trees pushed the wind."

PP James discovered not only that Momentum is a fallacious myth, but also discovered what he calls his "Plexiglas Principle" and the "Whirlpool Principle." The Plexiglas Principle says that if a team improves in one season, it will decline in the next. The Whirlpool Principle, Bill's refined version of his original idea, is that all teams are drawn strongly toward the mean. Most of the teams that had winning records in 2016 will decline in 2017, and most of the teams who had losing records will improve. Further, these regressions from improvement or decline will fit a pattern: about 70% of teams (or players, it turns out) which improve or have winning records in one year will decline in the next, and the amount of return toward the mean will be about 50% of the previous improvement or decline. Thus, if the Detroit Tigers or Miguel Cabrera slide downhill this season, there's a 70% chance next year will be better, and that the improvement will be 50% of the way back to their pre-2017 norm.

These James observations, repeated in his essays over the past quarter-century, comprise what he calls The Law of Competitive Balance. He's written, "There develop, over time, separate and unequal strategies adopted by winners and losers; the balance of those strategies favors the losers, and serves constantly to narrow the difference between the two." "The essence of the difference is in how winning and losing teams view the need to make changes. If the Dodgers are beating everybody, they don't want to mess with success, and will be slow to replace a 32-year-old third baseman who's had an off year. "We won the pennant with him, and he's sure to bounce back, and he's a great guy, and can still handle the glove." But the Phillies, mired in a quicksand of losses, will look for every way to improve, and will replace that aging third-bagger with a promising kid. Or, in a basketball example, Michigan leads Grunt State 33-28 with 8 minutes left in the first half, when Grunt State rips off 9 quick point and takes the lead. Who calls time out? Michigan. The announcer says, "Only a 4-point lead, but Grunt State really has the momentum going for them now." Michigan's Coach Beilein puts in a rebounder and a fresh wingman, but what can the Grunt State coach do? He is frozen by success; any change would seem loony. Michigan goes out and takes control. The overall sum of such moves, Complacency versus Urgency, generates the inexorable Law of Competitive Balance.

Bill James has wondered about, formulated questions to investigate, researched, and written about hundreds of issues of Baseball Wisdom since 1977.

- **PP** He's shown that championship teams are not teams that "Win the Close Ones." The best teams win a disproportionate number of games in lopsided fashion. In close games, where random luck plays an outsized role, weaker teams win closer to 50%.
- **PP** Baseball's infatuation with the relief Closer, dreamed up by Tony LaRussa in the 1980s, in which a team's best relief pitcher comes in only when his team is ahead and only in the 9th inning is preposterously nonsensical. The much smarter way to use your best relief pitcher would be to bring him into "high leverage" situations (which James has worked out) where the tide of the game could turn—for example in the 7th inning of a tie game with runners on first and second and only 1 out.

In 1986 James began to veer away from his involvement with pioneering studies of Baseball Wisdom toward another of his lifetime passions, baseball history, and, assisted by his wife Susie, he wrote and published *The Bill James Historical Baseball Extract*, which is even more captivating than it sounds. Fifteen years later he published a major revision and titled it *The New Bill James Historical Baseball Extract*. In these books he began the ambitious journey of writing a brief history of every major league baseball player in history, looking especially for what was interesting and worth commenting about in each man. The *BJHBA* walked through every decade of baseball's history from Old Hoss Radbourn and the fistfights of the 1890s to baseball's swamp of corruption that culminated in the 1919 World Series to the racial and economic upheavals of the 1950s to the nylon uniforms of the 1970s and the home run explosion of the 1990s, and offered such oddball categories in each decade as "A Better Man than a Ballplayer" and "A Better Ballplayer than a Man." It included Bill's quirky, researched, opinionated bios of all the great players and many others, included his essays, and presented James's lists of the greatest players in history and the greatest at each position, making the interesting and valuable distinction between Peak Value (players like Sandy Koufax and Jackie Robinson, whose careers were super but short) and Career Value (guys like Pete Rose, who was never super-duper but who was very good for a very long time).

James also wrote scintillating essays dissecting controversies about baseball rules, and riveting stuff about the Baseball Hall of Fame. Just two of the rules issues he took on had to do with dangerous situations inadequately governed by rules: one he called "Blocking and Tackling the Plate," the other "A History of the Beanball." 🌟

**** PP 8 **** Early in this talk I suggested that James's contributions to Baseball Wisdom can provide lessons for all of us outside baseball. I'll lead with a few examples of Bill James writing in his *Baseball Abstracts* about anything:

- ❖ **PP** "I could not describe myself as a statistician because I could not meet the standards statisticians would expect a professional statistician to meet. I don't call myself an auto mechanic because I'm afraid that somebody might ask me to fix their Honda, and I wouldn't have a clue how to do it. Self-definition is dangerous for a public figure, because it places limits on what one can attempt within that definition. I have always chosen to call myself a writer because, well, hell, anybody can call himself a writer."
- ❖ **PP** "It is my belief that most people, as they age, become parodies of the things they once believed in. In the context of life, confronted with an overwhelming array of options about what we should be and how we should make decisions, we choose to emphasize certain attributes that we find within ourselves. We select a philosophy of life as a man drifting in an infinite ocean selects a direction in which to sail his raft, because we are desperate to escape this bewildering ocean, youth. But once we reach land, having navigated the ocean, we begin to think that we really understand life. We forget that we once could see truth lying at the horizon in every direction. We begin to think that we are on the only land that there is, and that all who do not sail in our direction are doomed never to escape the sea. We assert our values without respect to the complexity of real life." We become parodies of our early beliefs.
- ❖ **PP** "If you believe in sports, then you must believe in stretching abilities to the limit. The sporting world is a refuge in a world of laziness and sloth, indecision and lack of commitment, hedged values and shortcuts—a corner in which individuals are commanded to reach down inside and find the best that's in there. Athletes are heroes; that is their job."
- ❖ **PP** "Creating knowledge to combat ignorance, creating tools with which to study something, these are slow and time-consuming activities. Making superstitious connections is quick and easy. That sounds judgmental and it shouldn't. The reality is that we're not capable of understanding the world, because the world is vastly more complicated than the human mind."
- ❖ **PP** "A secret is just a stage that information goes through on its way to becoming public. It may take an hour, it may take years, but the circle inside of which information is held grows inevitably larger and larger. It cannot grow smaller, and the boundaries of the circle are not firm enough to hold it in."

- ❖ **PP** “Everything depends upon recognizing what you do not know. We always want to focus on what we do know; we want to make inferences based on what we have studied in the past. But the problem is, you don’t learn anything by focusing on the stuff that you already know. You have to learn to embrace your ignorance. By doing so, you acquire the ability to expand knowledge.”

Finally, returning to his research, I’ll conclude with some life lessons I’ve either learned or had solidified for me by reading the baseball studies and essays of Bill James:

PP First, work really hard to *Ask the Right Questions* –not just the old standard ones –and, as much as is possible, answer those questions relying on the best, most focused available data. Use the scientific method to step outside the box of established wisdom and question whether it’s really wisdom at all.

Second, when making decisions regarding talent and organizational strength:

- 1) **PP** Remember the talent pyramid at the right-hand end of talent’s Bell curve, the wealth of available replacement-level talent. Never make do with a weak link or tolerate a bad team member.
- 2) **PP** Don’t trap yourself by over-estimating the value of star talent. Trust in *developing* talent, and in the wealth of talent that’s waiting for Opportunity to knock. Be like Whitey Herzog, Billy Bean, and Theo Epstein.
- 3) **PP** Build your quality organization through a pervasive depth of talent. Respect the value of every player’s contributions and elevate everyone’s confidence in the organization by striving for excellence at all levels. Remember that top-level success depends on the contributions of others. You can’t drive in runs unless others have worked their way into scoring position.

PP Fifth, look for perspective when judging success and failure. Hitting a lot of home runs in Coors Field in Denver doesn’t mean the same player will hit be as good a slugger in St. Louis.

Remember that being given a starting position of advantage or disadvantage can generate illusions of apparent success and apparent mediocrity. Being born on third base isn’t the same as hitting a triple.

PP Next, reject the Fake News of Momentum. Instead, even when riding a wave of success, grasp the constant need to adapt and improve. Never assume that, because you’ve done something well, the same approach will succeed at the next level. Be cautious of complacency when ahead and put hope in change when behind. Beware the Law of Competitive Balance, and pull away from the Magnetism toward the Mean.

PP Baseball teaches that an enjoyable workplace helps to generate success. What makes a successful big-league baseball manager? Managers who apply constant pressure, the Billy Martins of the world, often succeed in the short term, but the baseball season is 162 games long, and a team working together day after day needs community harmony. Managers who've succeeded over time with changing personnel, like Walter Alston and Bobby Cox, have been sage, steady shepherds. At the level of community, prima donnas and snarlers create disharmony. Character is not a substitute for ability, but is necessary for stable success.

PP Finally, value science over traditional mythology and hidebound beliefs. I am worried about our American culture's disastrous misunderstandings of and disaffection with science. We love everything science has done to make our lives work, from refrigerators and electricity to telephones to cars to computers and the internet to medical miracles and e-trading, but many disrespect the method of inquiry that is the scientific method: looking carefully at what actually is happening, generating best interpretations of that evidence, and constantly testing those conclusions. Stupidly, some people have come to think of the scientific pursuit of knowledge as "beliefs," as if science were a set of invented biases.

Bill James's scientific method has questioned tradition and norms, and has demanded answers better than past beliefs. James reminds us that, as we pursue knowledge and understanding, we are adrift in a Sea of Ignorance, and that we must value the contributions of others, the possibility of learning something new, and humility. James writes, "Basically, what I know about the scientific method would fit onto a bumper sticker. Scientists design tests to see whether an assertion is compatible or incompatible with the evidence. When they do that, someone else will always figure out some way to do another test, and a better test. When that happens, it is the scientist's responsibility to acknowledge that the other person's research is an advancement from his. What's necessary to the advancement of knowledge, then, is humility—the capacity to recognize that other people have accomplished something that we have not been able to accomplish. That, then is science's bumper sticker: **** PP 9 **** 'WHAT IS NECESSARY TO THE ADVANCEMENT OF KNOWLEDGE IS HUMILITY.'"

Maybe to the advancement of other things, too.