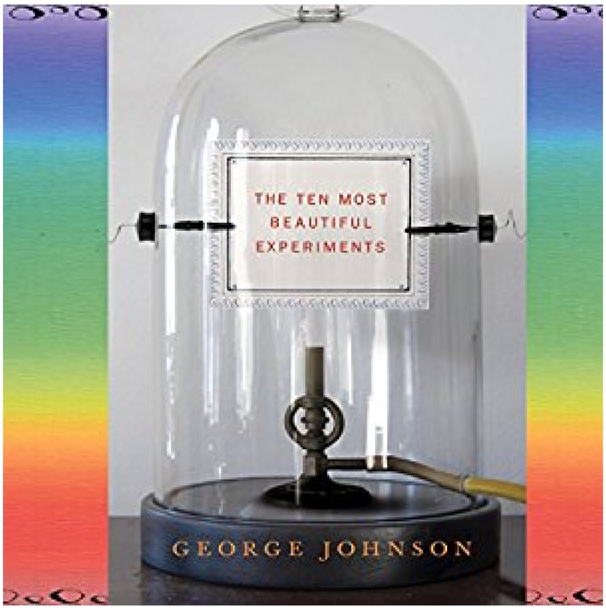
The Ten Most Beautiful Experiments



Synopsis

From the acclaimed New York Times science writer George Johnson, an irresistible book on the ten most fascinating experiments in the history of scienceâ ”moments when a curious soul posed a particularly eloquent question to nature and received a crisp, unambiguous reply. Johnson takes us to those times when the world seemed filled with mysterious forces, when scientists were dazzled by light, by electricity, and by the beating of the hearts they laid bare on the dissecting table. We see Galileo singing to mark time as he measures the pull of gravity, and Newton carefully inserting a needle behind his eye to learn how light causes vibrations in the retina. William Harvey ties a tourniquet around his arm and watches his arteries throb above and his veins bulge below, proving that blood circulates. Luigi Galvani sparks electrical currents in dissected frog legs, wondering at the twitching muscle fibers, and Ivan Pavlov makes his now-famous dogs salivate at ascending chord progressions.For all of them, diligence was rewarded. In an instant, confusion was swept aside and something new about nature leaped into view. In bringing us these stories, Johnson restores some of the romance to science, reminding us of the existential excitement of a single soul staring down the unknown. --This text refers to an out of print or unavailable edition of this title.

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Customer Reviews

Anyone involved in any scientific discipline should read this book. It is so important to understand the history of scientific exploration and where we fit in today. I have chosen to give descriptions of two of the experiments from this book in hopes to convey the atmosphere of the book. I think it is a really neat way to introduce some of the most important scientific discoveries in history as well as praise the genius it took to discover them."The Ten Most Beautiful Experiments", by George Johnson, is a novel written to energize readers about the intricacy and beauty of classic experiments. The author finds it important, in a day in which science has become industrialized and over-run with technology, that his readers are reminded of how some of the greatest discoveries in history came to be. The experiments were simple, often the work of one or two men, yet so elegant and genius that they continue to inspire generation after generation of thinkers. Johnsons begins with Galileo in the 17th century and ends with Robert Millikan in the 20th century, but also recreates many of the experiments himself. Johnson's experiences with the experimental methods and equipment provide a unique contrast which allows the reader to appreciate the skill the original discoverers must have used.Galileo:We now know that force = mass x acceleration. But Johnson reveals that the laws of motion confused men for centuries. While Aristotle made sensible observations, he had little grasp on the subjects of acceleration, force, friction, air resistance, etc. Galileo disproved Aristotle's "rules," but Aristotle is not forgotten because his "rules" laid the foundation upon which Galileo, and many others, built.Before religion burdened his curiosity, Galileo experimented with motion and showed that, in controlled conditions, "the speed at which an object falls is independent of its weight." But he still wondered why the falling objects gained speed as they dropped. Limitations in photography (they had watercolors) forced him to slow the motion of the drop for observation by erecting a smooth plane for the ball to travel through; during its fall, the ball would trip bells at different points on the track. The bells stood at increments of 1/4, 2/3, and 3/4 of the plane and the balls' descent to each point was timed (allegedly) by water clock. The measurements were taken again at different slopes of the plane.The water clock worked by drips of water which were weighed after each run of the ball--the more drips of water to fall meant more time had passed and the compared weights gave ratios to the distances the ball traveled during the allotted time. The idea of this experiment was highly scrutinized; some shamed it for its lack of precision while others believed it never actually took place, that Galileo staged it after deducing acceleration mathematically. Stillman Drake, in the early 1970s, pieced together missing pages of Galileo's experiment which had been discarded as scribbles. Whatever medium had been used to time the ball's intervals of movement was irrelevant as long as the time was constant, and Galileo's measurements showed that with each interval, the ball picked up more distance during the same amount of time. Because he noted next to these distances whether they seemed high or low, it is fair to assume Galileo had determined an equation for the increasing speed of the ball. On the manuscript, Galileo had written sequential squares: 4, 9, 16, 25, ... The distance the ball traveled was increasing with the square of the interval multiplied by the distance traveled in the first interval.

This finding allowed Galileo to debunk his critics centuries after his death and demonstrated that steeper slopes meant more speed, but by a predictable ratio.Drake did wonder how Galileo kept track of the intervals which occurred in fractions of seconds, a feat too difficult for a water clock. By recognizing the idea that musicians are able to time themselves in divisions of seconds, Galileo’s experiment was repeating using a 2-beat tune to mark the intervals. The method succeeded, and is widely believed to have been Galileo’s actual timing tool.Pavlov:Ivan Pavlov is quoted in the beginning of the chapter saying that the domestic canine is a creation of man and a frequent participant in man’s experiments. The dog’s loyalty to man is evident in its willingness to subject itself to man’s evolution of knowledge. Pavlov, though willing to expend his dogs to science, had enough of a relationship with each to name them. One of his firsts, a setter-collie mix named Druzhok (Buddy), was believed to be his favorite. Studying the mammalian digestive system, Pavlov described the "acute" animal experiments gruesomely and preferred the "chronic" approach where bodily fluids were collected while the dogs were under anesthesia. He was a first-class surgeon; once the dogs recovered from their trips under his knife, Pavlov could begin his observations.Pavlov began researching the nervous system in the early 1900s. Though he detested doing so, he would occasionally perform acute experiments which were fatal to his animals, but ultimately justified by the benefit to mankind. The dogs’ sacrifices were great, but they are immortalized by the knowledge Pavlov extracted from each death which has provided amazing insight into the brain.At one time, Pavlov was on the route to priesthood. But when Darwin and his On the Origin of Species, as well as other evolutionary and anatomical manuscripts, came into Pavlov’s reach, he became addicted to the scientific readings. In "Reflexes of the Brain", Ivan Sechinov attributed every single human action to reflexes--muscular movements dictated by the brain. He believed reflexes were responsible for even spontaneous ideas as a result of subconscious cues. He foresaw a time when knowledge of the brain would be as keen as any other science and that these "reflexes" would become entirely predictable.Intrigued by such notions, the young Ivan Pavlov redirected his study of the church to that of science. In Saint Petersburg in 1870, he studied chemistry under Mendeleyev. Ivan gravitated toward physiology and earned his doctorate through research on the nervous system of canines and its control over cardiovascular processes. By 1891 he was the head of the physiology department of the Institute for Experimental Medicine. It was there that his surgical skill allowed him to map the cascade of reactions which occur in the gastrointestinal tract.The saliva, a mix of water and mucin, was present to lubricate the passage food took to the stomach. The stomach held "appetite juice" as well as nervous sensors, also present in the duodenum, which signaled for the preparation of gastric juices specific to whatever food needed to be digested. But

Pavlov was curious about the saliva; it was still present even when the dog tasted something unappetizing, just in a form free of gastric secretions. Perhaps this watery saliva functioned purely to cleanse the palate of the unpotable substance, but how did the body sense the difference?Pavlov sought to measure the amount and composition of the saliva by first surgically relocating the ductile opening of one of the dog's salivary glands to the outside chin or cheek. Upon recovery, he collected fluid to be analyzed. No saliva was released for pebbles of quartz. Water was elicited by white sand to wash it out. Dry bread called for a lot of drool to lubricate it adequately. And a savory chunk of meat required drool as well, but in a smaller quantity. It seemed that evolution had dictated specific salivary responses based on the animals' environments.Pavlov believed that the animals' reflexes allowed for various responses to balance various stimuli. For his studies on the physiology of digestion, Pavlov was awarded a Nobel Prize in 1904. Soon after, his work was ridiculed for its exclusion of the role of hormones. With that, Pavlov moved on from digestion to study a subject he deemed more important--the nervous system.The food did not actually have to be ingested to cause the dogs' salivation. Learned responses to cues for mealtime and smells were capable of inciting these "psychic secretions". The learned responses were not entirely instinctual, so Pavlov found he could modify them. It isn't hard to imagine Pavlov thinking of creating specific learned responses, or adaptations, as his own brand of microevolution.In the beginning of his "inhibition" of reflexes, when the animal ceased to drool after repeatedly being shown meat, Pavlov might have thought the responses to be psychological--a sort of frustration by the dog, if you will. But he would have been quickly corrected by the fact that a taste of acid would cause the salivation to return. Were the responses products of the dogs' thoughts, this would not be the case. And just as humans lack ESP, trying to read the thoughts of a dog would be a futile venture at best.Pavlov was becoming confused between mental and physical physiology. His previous research had been in the form of mechanical action-reaction observations where gray areas were few and far between. In order to study the central nervous system, he would need to separate his subjective self from the animals' internal state; he could no longer "measure" his results because the psychological ideas were immeasurable. He started with what he knew to be fact: environmental factors (which cued the firing of receptors somewhere) were responsible for the salivary glands' physiological reactions.In the 17th century, Descartes philosophized about organisms' existences as biological machines bound to the universal laws of physics. But like many great thinkers to come, he acknowledged that the human brain defied the boundaries of any other organism; the human mind was on a whole new level of intelligence. The idea was a quid pro quo because with Darwin's theory of natural selection also came the skepticism of how the mind could be naturally selected. William James simplified the dilemma as though the atoms of matter which form the brain somehow, over eons, oriented themselves in greater and greater conformations. The understanding of the brain and its functions was also described by Thomas Henry Huxley as one half of a team; for every chemical bodily action there is a mental counterpart. Basically, a body part does not move without the brain first directing it to do so. James, however, felt the mind to be a more romantic idea and that beings are not simply organic machines but something science could not explain.Pavlov didn’t care to debate such things he could not support by fact. He preferred to learn about his subjects’ minds from the outside, leaving no room for speculation. When a dog salivated at the smell of meat, it was natural, yet also a learned response to its experiences. He could modify the response by employing a second stimulus along with the meat which, by itself, would eventually cause salivation on its own.Even though pairing meat with a stimulus would naturally peak a dog’s interest (food is inherent to survival), Pavlov learned he could also modify this learned behavior with unsavory tastes, such as when the dogs tasted dilute acid which had been dyed black. The acid promoted salivation, and once the dog associated its response with the sight of black liquid, the sight of such alone provoked the drooling. The response could also be undone; once the dog learned the black water was without acid, the drooling response would disappear.It’s almost sadistic to cause and reverse neural connections so repeatedly, but Pavlov became well practiced in the art, knowing it was for the good of science. He was even able to change the timing of the dogs’ salivations by varying the time of the stimulus. He went on to turn time itself into a stimulus; he could feed a dog at fixed intervals and when an interval hit with no food, the salivation would still occur. In order to discriminate between such innocuous stimuli like the direction of an object’s rotation, the dogs, Pavlov thought, must possess keen neural machinery. They were able to distinguish between musical notes, shades of gray, and could even count.The experiments had to occur with strict integrity to produce meaningful data. There had to be no distractions or changes which could compromise the dogs’ entrainment, so Pavlov ordered the construction of a "Tower of Silence". It was completely protected from external sound and vibrations; the observations were taken through periscopes to avoid contact with the specimen. Countless hypotheses were tested in the facility and they produced a conglomeration of beautiful experiments; one stood apart from the rest.Pavlov could already elicit salivation musically. And if a dog learned to drool to a specific chord, it would also drool (though to a lesser extent) to the individual notes which comprised the chord. The researchers progressed to melodies. After playing four notes in ascension, food was given. When the notes were played in reverse, no food was given. The dogs could distinguish between the two, but then they were exposed to 22 other combinations of notes. Collecting saliva to gauge the responses, the researchers found the dogs had categorized the melodies based on whether the scales rose or fell. The dogs' brains held potential, just like humans'.Debate continued over the matters of psychology. Some though the process entirely predictable while others believed each response was unique. Even now we are torn between nature and nurture, but perhaps our time is better spent on the things we do known and the appreciation of such. Our debt to the canines who agreeably permitted their lives to be used for the advancement of science may never be paid, but like the many pieces of knowledge they provided, maybe we can all spend a little more time with our furry pals and it will add up to one big, beautiful thank-you.

In this beautifully written book, Johnson brings together some of the most important scientific experiments in history. The thing about experiments, however, is that rarely are they famous. Boring, repetitious, and often failures, Johnson sheds new light on some of history's most important experiments and how they shaped our world in ways that we never have imagined.While he does invoke some rather large names (Newton and Faraday, for example) he also gives insight on lesser known scientists who performed lives of such extraordinary discipline to their craft that our world has forever been shaped by their methods. What is most interesting about this book, however, is Johnson's steadfast focus on the beauty of the journey and how that journey shaped the life of the scientist, not the benefit towards some ephemeral scientific canon.

Very well written book with great perspective on some of the key scientific experiments in our history. I love that not only does the author explain the experiments in detail, but also how the opinions of the scientific community before the tests were done affected the experimenter, and how the results of the experimented in-turn affected the rest of the world. It's much more than just a description of just what the experiment performed, as the added context provides insight into the researchers impacts.

If one asked a group of scientists to list the most significant scientific experiments of all time, a number of the experiments in this book would no doubt make the list. But that's not what the author is saying here. He might have as easily titled his book "The Ten Most Elegant Scientific Experiments," and that's how I see it. Today, when many of the most important scientific questions are being investigated via apparatus that costs millions or even billions of dollars ($2.5+ Billion for the Hubble, and $9 billion for the Large Hadron collider, for example) it is both instructive and fascinating to see how some of the most puzzling questions of the past were answered through the use of very simple apparatus. Gallileo used nothing more than (it is conjectured) a slanted track and a small ball to derive the basic equations of gravity: Distance traveled equals the square of the time elapsed multiplied by a constant. Newton solved the problem of the composition of light using a pair of prisms.Not all of the experiments described here were that simple. Michelson and Morley's investigation into the ether required the construction of a precise optical apparatus requiring the skills of a machinist and an optician, though it certainly cost far less than a space telescope. What underlies all the experiments Johnson describes is a certain simplicity, an elegance in the way the question was asked or tested. Michelson's interferometer experiment started with the realization that if we are in fact traveling through the "luminiferous ether", then light should travel faster when measured in one direction than in another. While his actual experimental trials were painstakingly precise and numerous, they amounted to something very simple: Look at the interference patterns, rotate the device, and look again. EIther you see a change- or you don't. He didn't, and that sealed the end of the ether hypothesis.Miliken's experiment- which also required a bit of laboratory apparatus- was deceptively simple: Measure the electrostatic charge needed to support a tiny drop of oil against the force of gravity. You had no way of actually knowing the number of atoms in an oil drop, and while the size of a drop could be measured, and the number of atoms estimated, Miliken had an insight: The charge would always be a multiple of the charge needed to suspend one atom, and form that, he could take a large number of trials and find the lowest common multiplier, as it were. SImple. Elegant. And, if you like, beautiful.George Johnson is one of the best popular science writers on the modern era, a man who can present some of the most cutting edge ideas- quantum computing, for example- in a way that goes beyond the metaphors used by most popular science writers- the "gravity is like a BB on a rubber sheet" school of science writing Part of that is his ability to bring the reader along on the same line of reasoning and insight that led him to understand a topic, and I think he's done an excellent job of that here. Each experiment is discussed both in the context of the history of the idea, and how the scientist in question came to design his experiment. The result is clear, thought-rpovoking reading for anyone with a basic understanding of science.Like some reviewers, I would have liked to see more contemporary illustrations, in addition to the contemporary illustrations that accompany each experiment. The reader familiar with interference patterns might not have trouble understanding the discussion of the Michelson interferometer, but someone less well read in physics might benefit from a clearer diagram of what's going on. Still, this is a very enjoyable and informative book, and even those who are familiar with all the experiments discussed will, like this reader, learn quite a bit more about each of them.

The Ten Most Beautiful Experiments The Most Beautiful Villages and Towns of the Pacific Northwest (The Most Beautiful Villages) The Most Beautiful Country Towns of England (Most Beautiful Villages Series) The Most Beautiful Country Towns of Provence (Most Beautiful Villages) The Most Beautiful Villages of New England (Most Beautiful Villages) The Everything Kids' Easy Science Experiments Book: Explore the world of science through quick and fun experiments! (EverythingÂ® Kids) Science Experiments For Kids: 40 + Cool Kids Science Experiments (A Fun & Safe Kids Science Experiment Book) Garbage and Recycling: Environmental Facts and Experiments (Young Discoverers: Environmental Facts and Experiments) Environmental Experiments About Air (Science Experiments for Young People) Dad's Book of Awesome Science Experiments: From Boiling Ice and Exploding Soap to Erupting Volcanoes and Launching Rockets, 30 Inventive Experiments to Excite the Whole Family! (Dads Book of Awesome) Space and Astronomy Experiments (Facts on File Science Experiments) Simple Machine Experiments Using Seesaws, Wheels, Pulleys, and More: One Hour or Less Science Experiments (Last-Minute Science Projects) Genetics Experiments (Facts on File Science Experiments) Human Body Experiments (Facts on File Science Experiments) Rain Forest Experiments: 10 Science Experiments in One Hour or Less (Last Minute Science Projects with Biomes) Weather and Climate Experiments (Facts on File Science Experiments) Experiments for Future Forensic Scientists (Experiments for Future Stem Professionals) Physical Science Experiments (Facts on File Science Experiments) Ecology Experiments (Facts on File Science Experiments) Environmental Science Experiments (Facts on File Science Experiments)