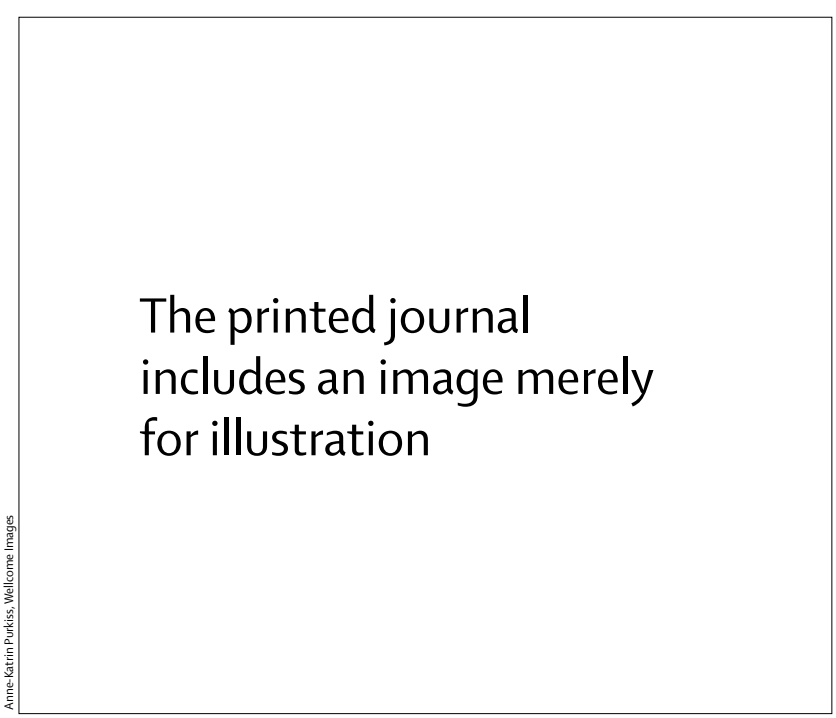
The art of medicine:
Perspiration, inspiration, and the 10-year rule

Gradual preparation with sudden illumination, dogged work with a "eureka" experience, perspiration with inspiration—whichever pair of contrasts one prefers—are defining features of creative breakthroughs in any domain of science or art. "Before the gates of Excellence the high gods have placed sweat", said an unnamed ancient Greek poet, probably Hesiod. In Thomas Edison's much-quoted remark, from around 1903, "Genius is one per cent inspiration, ninety-nine per cent perspiration." Another version of this idea, attributed to George Bernard Shaw, alters the proportions to "ninety per cent perspiration, ten per cent inspiration".

Late in life, Charles Darwin made the same basic point less pithily but with profound insight in a letter to his son Horace: "I have been speculating last night what makes a man a discoverer of undiscovered things, and a most perplexing problem it is.—Many men who are very clever,—much cleverer than the discoverers—never originate anything. As far as I can conjecture, the art consists in habitually searching for causes or meaning of everything which occurs. This implies sharp observation and requires as much knowledge as possible of the subject investigated." Certainly, Darwin was a relentless student of nature from 1828 until the few weeks in late 1838 when he suddenly perceived the basic mechanism of evolution by natural selection.



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Alec Jeffreys, who developed genetic fingerprinting in what he said was a "eureka moment"

There can be no doubt that geniuses have worked habitually and continually. Darwin produced some 160 published papers, in addition to celebrated books and a vast correspondence, still being edited and published. Albert Einstein had 240 publications, Sigmund Freud 330, Henri Poincaré 500 papers and 30 books; Edison was the owner of 1093 patents, lodging an average of one patent every 2 weeks of his adult life. In the arts, J S Bach on average composed 20 pages of finished music per day, while Pablo Picasso created more than 20 000 works. Although not quite so well known, the physician and polymath Thomas Young—"the last man who knew everything"—also worked indefatigably. When he lay dying in 1829 in his mid-fifties, able to manage only a pencil, Young corrected the proofs of his *Rudiments of an Egyptian Dictionary*. As a physician, he had a better idea of his medical condition than most patients have. But when a close friend remonstrated with him that the writing would exhaust him, Young answered: "that it was a work which if he should live it would be a satisfaction to him to have finished, but that if it were otherwise, which seemed most probable, as he had never witnessed a complaint which appeared to make more rapid progress, it would still be a great satisfaction to him never to have spent an idle day in his life."

Long years of relevant labour have often preceded a scientific breakthrough. In medicine, Alexander Fleming had been working in the bacteriology department of a London hospital for some two decades when he discovered penicillin in 1928. During World War I, he became interested in finding antibiotics to treat sepsis in wounds. After the war, he began an active programme of research; in 1922 he discovered the antibiotic enzyme lysozyme in nasal mucus, tears, and saliva. So he was well prepared to recognise the importance of the bacteria-killing mould *Penicillium* when he chanced upon it.

Similarly, Alec Jeffreys discovered the underlying concept of genetic fingerprinting by accident, while investigating how inherited illnesses such as cystic fibrosis were passed through families. In order to trace genes through family lineages, Jeffreys had identified a fragment of DNA that repeated on different chromosomes in the cells of men and women. He had then devised a technique, by tagging the DNA fragment with a radioactive molecule, to count these repeated sections on radiographs in different individuals and their relatives. Having left the experiment running over the weekend, he returned to his laboratory on a Monday morning in 1984 to find a peculiar array of blobs and lines on the developed film. His first reaction was: "God, what a mess." But when he stared at the data a bit longer, "The penny dropped." Each sequence of bars on the film represented a different number of DNA repeats: a bar code that was unique to an individual

and was also a composite of the DNA of the individual's father and mother. "It was an absolute eureka moment", Jeffreys said later. But the penny would not have dropped without his more than a decade of prior research in genetics.

Like the discovery of penicillin, DNA fingerprinting is a fine example of Louis Pasteur's 1854 dictum: "Where observation is concerned, chance favours only the prepared mind." Can we today be more specific than Pasteur? Perhaps. Although genius does not follow laws, it seems to follow the so-called 10-year rule. First identified by the psychologist John Hayes in 1989 and soon endorsed by other psychologists, the rule states that a person must persevere with learning and practising a craft or discipline for about 10 years before he or she can make a breakthrough. Remarkably few breakthroughs have been achieved in less than this time. The initial scientific evidence for the rule came from studies in the 1960s and 1970s of chess-players, who take 10 years and more to become masters of the game. Then it was found to apply to Olympic swimmers and concert pianists. Subsequent studies of scientists and mathematicians, composers, painters, and poets—living and deceased—further supported the rule.

In the sciences, Darwin is a good example. So is Einstein, whose first insight into the basis of special relativity occurred around 1895, 10 years before the creation and publication of the theory in 1905. Michael Faraday demonstrated the electromagnetic principles of the motor and the dynamo in 1821, a decade after he began studying science in 1810. August Kekulé's theory of the benzene ring was published in 1865, 10 years after his first day-dream of his structural theory on a London omnibus. Tim Berners-Lee invented the World Wide Web in 1990, 10 years after his first web-like computer program, known as Enquire. It is not difficult to multiply examples.

The arts frequently show the rule in operation, too—if "breakthrough" is defined as the production of an artist's first generally accepted masterwork. In literature, Percy Bysshe Shelley's creative explosion of 1819–20 occurred 10 years after he wrote and published his first poetry and fiction in 1809–10; whilst Ernest Hemingway's *The Sun Also Rises* was written in 1925–26, 10 years after he began publishing fiction and journalism in his school magazine. In painting, Pablo Picasso's *Les Demoiselles d'Avignon* was created in 1907, a decade after he began training as an artist in Barcelona in 1896. In music, Igor Stravinsky's *The Rite of Spring* was composed in 1912, a decade after he began his apprenticeship to Nikolai Rimsky-Korsakov in 1902.

In my view, the 10-year rule is best considered in three versions: weak, medium, and strong. The weak version is that a breakthrough requires a minimum of 10 years' hard work and practice in a relevant domain—and it may take much longer. The medium version is more restrictive: a breakthrough requires a minimum of 10 years' hard work and practice focused on the particular problem solved by the breakthrough. The strong version is more restrictive still: a breakthrough requires about 10 years—no less and no more—of hard work and practice focused on the particular problem solved by the breakthrough. Of course, there are many exceptions to the strong version, such as Fleming and penicillin. However, exceptions to the weak version of the rule—in which a scientist or artist makes a breakthrough after less than 10 years of hard work and practice in a domain—are rare. Not even Wolfgang Amadeus Mozart fits this last bill, since his first masterwork, his piano concerto No 9 (K271), was written in 1777, which is 12 years after his first published composition.

Hayes discovered only three exceptions among classical composers: Erik Satie composed a masterwork in year 8 of his career, while Niccolò Paganini and Dmitry Shostakovich composed one masterwork each in year 9 of their careers. In the sciences, exceptions are extremely rare. The theoretical physicist Werner Heisenberg created matrix mechanics in 1925, aged 24 years, only about 5 years after beginning his university study of physics. On the other hand, Heisenberg had two leading physicists, Max Born and Niels Bohr, as close mentors during this period. Paul Dirac, another great theoretical physicist, may provide a further exception: in 1928, he formulated the relativistic theory of the electron from which he predicted the existence of the positron, aged 25 years, about 6 years after beginning his university training in applied mathematics. However, Dirac had previously taken a 3-year degree in electrical engineering. Perhaps only Isaac Newton fairly and squarely beats the 10-year rule in science: his *annus mirabilis*, 1665–66, occurred after less than 5 years of solitary study at Cambridge, at the age of only 22 years.

The predominance of theoretical physics among the handful of exceptions may be a small clue to the explanation of the 10-year rule in exceptional creativity. In theoretical physics, years of laboratory grind are not required, nor is any of the corpus of facts about nature that has to be memorised and assimilated in other sciences, such as biology and medicine. So perhaps the theoretical physicist needs to expend less time in perspiration than other scientists before he or she can reach the frontier of the subject and make a breakthrough. Indeed, the 10-year rule seems to me to be an empirical truth about perspiration and inspiration equivalent to that of Edison's personal guess—not only in its underlying rationale but also approximately in its ratio. Instead of Edison's 99% versus 1% estimate, for every 10 years (120 months) of hard work, an individual may be granted, so to speak, a month or two's worth (1%) of "sudden inspiration". Discouraging as this may be in one sense, it also means that hardly any genius in history—not even Leonardo da Vinci—seems to have short-cut the long and gradual path to creative breakthroughs.

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Further reading

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