Vol. XV Part 1 The British Journal of Statistical Psychology May 1962

FRANCIS GALTON AND HIS CONTRIBUTIONS TO PSYCHOLOGY

By CYRIL BURT[1]
University College, London

When I was a boy, my father, who was a country doctor, used to take me on his rounds to visit his patients. Of these by far the most impressive was the squire of a neighbouring village called Claverdon, a small Warwickshire hamlet, lying between Stratford-on-Avon and Birmingham.[2] The squire was an octogenarian named Darwin Galton. On his mother's side he was the grandson of Erasmus Darwin, physician, zoologist, botanist, and poet, and on his father's of a Birmingham Quaker who had made his money by manufacturing rifles. He himself was the eldest son in a family of nine. And, when he was fit, I was sometimes taken up to see him, and so met many other members of the same family, including the youngest, called Frank or Francis.

Francis Galton was one of the most distinguished-looking people I have ever known—tall, slim, neatly dressed, with a forehead like the dome of St. Paul's. My father, who was an ardent Darwinian, used to try to inspire me with intellectual ambitions of my own by telling me of the remarkable investigations carried out and published by this exceptionally brilliant member of an exceptionally brilliant family. I met him again as an undergraduate at Oxford, and later in London shortly before his death. He died in January, 1911, at Haslemere

[1] Barely eighteen months ago psychologists were celebrating the hundredth anniversary of the publication of Fechner's *Elemente der Psychophysik*. The year 1860, which witnessed its appearance, also marked the birth of Francis Galton's interest in statistical methods as applied to the problems of individual differences. And in the following year, the fiftieth anniversary of Galton's death, the British Association and the British Psychological Society determined to commemorate his life and work by arranging a discussion of his many contributions to various sciences, and their value as assessed after half a century's progress. Professor Burt was accordingly invited to prepare a review of his psychological researches for the Annual Conference held at the beginning of the year; and the substance of that paper is presented in the following pages.

A shorter version was published in the Society's *Bulletin* for September 1961. The fuller account is printed here at the request of several readers who were unable to attend the meeting. We are grateful to the editor of the *Bulletin* for permission to repeat passages that appeared in its pages, and to Mr. J. C. Kenna, who keeps the Society's archives, for supplying some of the dates and incidental details. (*Editorial Note.*)

[2] Plate XXIX in volume I of the *Life and Letters* reproduces sketches of the mansion and church at Claverdon as they appeared during my boyhood. On Darwin Galton's death in 1903 Francis's nephew, Mr. Wheler Galton, inherited the Claverdon estate, and there (as readers of Pearson's biography will recall) collected a veritable museum of portraits and *personalia* relating to Francis and his various ancestors. My own family lived about four miles away in an old rambling house, where, as it happened, Mr. Wheler Galton had been born. This coincidence further strengthened the friendship between my family and the Galtons, particularly when Wheler Galton in his turn became my father's patient.

(Surrey), in a house he had taken to escape the London winter; and his body now lies in the family vault in Claverdon churchyard. His biography, in four large quarto volumes, was compiled by his friend and disciple, Karl Pearson, my former colleague at University College.[1] It is largely to that work—supplemented by Galton's *Memories*, by my own recollections of him, and by the reminiscences of other members of his family—together with relevant articles in the *Dictionary of National Biography* and elsewhere, that I am indebted for the details summarized here. My aim, however, will be not so much to record or repeat the well established facts, but rather to interpret them.

I. Birth and Ancestry

Francis, the youngest son of Samuel Tertius Galton and Violetta Darwin, was born on February 16, 1822, at the Larches—a country house a mile and half from Birmingham where his father was partner in a large bank.[2] 1822 was by a curious coincidence the year in which another great hereditarian was born—the Abbé Mendel; and it is chiefly as the champion of heredity and the apostle of eugenics that we find Francis Galton depicted in Pearson's biography. He himself presents a most instructive example of inheritance; and the pedigree of his family, which Pearson traces back through a dozen or more generations, must be one of the most thorough genealogical studies in existence. Anyone who attempts to follow Francis's remarkable career will be struck by the fact that it is not in the least what one might have predicted from a knowledge of his closest relatives or his home environment. It was certainly not what his parents either anticipated or hoped for. Many of its unexpected turns can, I think, only be explained by his peculiar ancestry. Fortunately information about the various stocks from which he was descended is available in considerable detail; and a closer study may serve to illustrate in the concrete several of the debatable topics that have been raised in recent volumes of this *Journal*—the steady rise of highly intelligent stocks from humble beginnings, their marked tendency towards interbreeding or assortative mating, the occasional outbreeding, the intermittent appearance of distinctive traits both of intellect and of temperament, and finally the subtle influence of changing social and economic conditions and of the cumulative traditions that develop within such families.

The story of the Galtons is typical of the ancestral history of many eminent persons belonging to what today we should call the professional classes. Working

[1] Karl Pearson, *The Life, Letters and Labours of Francis Galton*, Vol. I, 1914; Vol. II, 1924; Vols. III A and III B, 1930 (Cambridge University Press). Francis Galton, *Memories of My Life*, 1908 (Methuen).

[2] The house, or rather its predecessor, had belonged to Dr. Joseph Priestley, the discoverer of oxygen. Most of the original building and his laboratory had been almost completely wrecked by the Birmingham mob some thirty years before, on the second anniversary of the French Revolution. Priestley was a close friend of Francis's grandfather, Erasmus Darwin; and Samuel Tertius Galton had partly financed his experiments. Samuel Tertius took the house for a few years before buying Claverdon Leys; and it was in the meadows belonging to it that Charles Darwin and the Galton boys learnt to ride and to shoot.

backwards, we come first to the well-to-do father or grandfather—a successful man of business, then to the shrewd and industrious shopkeeper, and so eventually to the older yeomanry, the small farmer, and the ' rude forefathers of the hamlet ', sleeping beneath their scarcely legible tombstones in the village churchyard. And here our records begin to fail us. Yet often in one or two contributory branches there are strands which may carry bits of the pedigree back farther still to some knighted or ennobled kinsman about whom a good deal more is known. At every stage social mobility proves to be quite as important as social origin; and the investigator begins to recognize that yeoman, squire, baron, and king are all members of a single social hierarchy which is far more homogeneous and intermixed than our current ideas of class distinction are apt to suggest.

On the paternal side, the oldest members of the Galton family seem to have been natives of the village of Galton, in the county of Dorset, farming or working on the land around. As commonly happened, the younger sons migrated first to neighbouring villages, and then to the larger towns, where some of them set up as retail traders. Later, when the industrial revolution arrived, they or their descendants became organizers of flourishing mercantile concerns. Thus, during the short reign of James II we find a certain Robert Galton starting a modest business as ' haberdasher of small wares ' at Bristol—the nearest large city, and in those days second in importance only to London.[1] Robert was followed a little later by several other members of the family. John Galton, Robert's brother, joined the Society of Friends; and in 1703 married Sarah Button, whose father had been imprisoned as a Quaker. Indeed, out of Francis's sixteen great-great-great-grandparents on the paternal side more than a dozen were adherents of this sect. Stringently selected as the early Quakers were, their rules of intermarriage produced a stern and stubborn breed of highly competent men and women, many of whose descendants are household names today. However, among the early Galtons, John's grandson, Samuel the Second (as he may be called) was almost the only man of note. He moved from Bristol to Birmingham, and married another Quakeress, Lucy Barclay. There he became a member of the Lunar Society, which included Priestley, Watt, Wedgwood, Baskerville the printer, and Erasmus Darwin. Samuel's hobbies were optics and astronomy: University College now possesses a complicated orrery that he once purchased. It was apparently his experiments on colour-mixture which first suggested to his youthful friend, Thomas Young (another Quaker, brought up by the Barclays) those famous researches that led to the three-colour theory.[2]

[1] For a vivid account of social conditions at that time see Macaulay's *History*, chap. III, ' The State of England in 1685 '. The name Galton is still legible on tombstones in the churchyard at Yatton, a parish in the adjacent county of Somerset, about 12 miles south-west of Bristol.

[2] Thomas Young, *Lectures on Natural Philosophy* (1807). In passing we may note that Young was yet another of those infant prodigies with which Quaker families seem to have abounded—a genius who, strangely enough, finds no place in the Terman–Cox studies. Mathematician, physicist, physician, linguist, antiquarian, scholar, and a Fellow of the Royal Society when only 21, he might serve as a striking instance of an innate intelligence that was truly general.

Nominated by Joseph Priestley, Samuel was the first of the Galtons to be elected a Fellow of the Royal Society. His mechanical skill made him, like Baskerville, a successful maker of guns. But eventually he determined to concentrate talents that might have made him a leading physicist or mathematician on the problems of finance. He died a wealthy banker, worth £300,000. His son, Samuel Tertius, the oldest surviving son in a family of ten, inherited the business.[1] He was elected High Bailiff of Birmingham, and later Deputy-Lieutenant of the county. In 1807 he married Violetta, daughter of Erasmus Darwin, and so became the father of Darwin Galton and of Francis.

On the paternal side, however, the most interesting ingredients were contributed not by the Galtons, but by the Barclays. The Barclays (or Berkeleys, as they were known in Gloucestershire) are one of the three English families which can be traced back to pre-Norman times. Perhaps the most famous was Colonel David Barclay of Ury, a soldier of fortune, who served under Gustavus Adolphus and in our own civil war, " brandishing a sword which other men could scarcely lift ". When he was fifty, so he tells us, he made up his mind to " change to the service of God ", and joined the Society of Friends. American readers will remember Whittier's stirring ballad:

Up the streets of Aberdeen,
By the kirk and College Green,
Rode the Laird of Ury.

Eventually the Quaker Laird married the daughter of another famous Scottish clan, Catherine Gordon. It was their son, Robert Barclay, ' the Apologist ', a scholar and a master of English prose, who formulated the traditional doctrines of the Society of Friends. Being himself a direct descendant of the Stuarts, he was able to appeal successfully to James II to check the persecution of his sect. It is, however, surprising to find his sister Jean marrying another rough and reckless warrior, Sir Ewan Cameron of Lochiel surnamed ' the Black '. He was one of the last of the great Scottish chieftains, and in 1689 summoned his clan to join the Jacobite rising to defeat William's lowland regiments at Killiecrankie. Macaulay describes him as ' the Ulysses of the

[1] Samuel the Third inherited none of Samuel the Second's vigour or versatility. But he possessed the same aptitude for applying quantitative methods to practical problems, and published a small book on currency, with tables. Pearson contends that he passed on his business aptitudes, together with the family's almost obsessive passion for organizing and classifying everything, to his son, Francis. The feminine relatives displayed a similar fondness for method in everyday affairs—filing, labelling, indexing, record-keeping (sometimes with the help of three coloured inks). My father used to say that Darwin Galton managed the Claverdon estate with all the systematic efficiency of a scientist; Darwin Galton himself attributed his innovations rather to the business traditions of a family of Quaker merchants. From Francis's youthful letters one might infer that in his case " the business-like habit of daily book-keeping " was painfully acquired under his father's watchful eye. One of his letters home declares he has now become so well disciplined that " even if I wish to give coppers to a crossing-sweeper, I no longer feel in my trousers; I pull out my pocket book, and examine the balance ".

Highlands '.[1] He lived to be ninety. The progeny of this union were men and women of vigorous health and great physical strength, long-lived, and full of the spirit of wild adventure. Their grandson, a Member of Parliament, is reported to have hurled a trespassing donkey over a hedge " as easily as he would a cushion ". His son, Captain Robert Barclay, Francis's great-uncle, was a keen agricultural reformer, and an athlete who " once walked a 1,000 successive miles in a 1,000 successive hours ". When as an old man of 70 he was dining with the Galtons, he lifted Francis's eldest brother (who weighed 12 stone) on the palm of one hand from the floor to the table. It was to this Barclay-Cameron blood that Francis himself ascribed his own " physical toughness and unusual power of enduring bodily fatigue ".[2]

Let us now turn to Francis Galton's ancestry on the maternal side. The earlier Darwins, like the earlier Galtons, comprise few names of note. The pedigree starts about 1500 with four generations of Lincolnshire yeomen. In 1650 one of the younger members of the family became a London lawyer, a member of Lincoln's Inn, and married the daughter of a still more eminent lawyer, Erasmus Earle, ancestor of the novelist Bulwer Lytton, and Own Serjeant to the Commonwealth. Their great-grandson was Erasmus Darwin, M.D., F.R.S., famous in his day as the author of several philosophical poems on biological subjects.[3]

[1] *History of England*, ch. XIII, which summarizes his remarkable exploits. " Tall and strongly built," says Macaulay, " he was in personal qualities unrivalled among the Celtic princes." The most celebrated of his hand-to-hand fights was the model for the fight between Roderick Dhu (' the Black ') and Fitzjames in Scott's *Lady of the Lake*.

[2] *Memories*, pp. 5, 11. According to contemporary accounts he walked one mile in each hour, and so never slept for more than 70 minutes on end for the whole six weeks. Dr. Barbara Moore, we may recall, completed 871 miles in 526 hours. Many other relevant stories of Galton's Scottish ancestors are related by his elder sister in her *Reminiscences*. She and Francis visited Ury in 1839, and saw the old house with its secret chambers. Their hostess, Margaret Barclay, showed them a miniature of Queen Anne, set with diamonds, presented by the Queen to their Jacobite ancestor, and gave them a hair from Prince Charlie's locks. A branch of the same family later founded Barclay's prosperous bank. One other Quaker family deserves a passing glance—the Freames, who intermarried more than once with the Barclays, and so contributed to the Galton stock. They too exhibit the usual fourfold type of ' social mobility ', beginning as humble farmers, then changing to retail traders, and so to large-scale business, with men of the professional class—clergy, lawyers, and scholars—emerging in the later stages. Their genealogy begins with Robert Freame of Cirencester. His granddaughter married the son of Barclay, the Apologist, and was thus a direct ancestor of Francis. Her father started as a local grocer, and later transferred his business to Lombard Street; her brother, who inherited it, became a Lombard Street banker, and his son-in-law in turn became a partner of Samuel Galton, the Birmingham banker; her cousin emigrated to Philadelphia, and married the daughter of another famous Quaker, William Penn. The Freame pedigree includes Elizabeth Fry, the prison reformer (the Frys were another Quaker family who established the well known chocolate firm at Bristol), William Wordsworth, Christopher Wordsworth (Master of Trinity and brother of the poet), three other Wordsworths who became bishops, Elizabeth Wordsworth (Principal of Lady Margaret Hall), and yet another Fellow of the Royal Society (Sir William Watson).

[3] E.g. *The Loves of Plants* (1789) and *Zoonomia* (1794). As de Candolle observes, these " hit the mood of the moment, but Canning's parody, *The Loves of Triangles*, killed poor Darwin's reputation ". Erasmus's brother, the first Robert Waring Darwin, was the author of a *Principia Botanica* which ran through several editions. There is, however no hint of any scientific bias

Erasmus Darwin married twice; and with each of the two families we encounter stocks of entirely different types from those we have met with hitherto. His first wife was Mary Howard, grand-mother of Charles Darwin. Through her ancestors the Darwin family is linked with some of the most active and famous representatives of the British aristocracy and royalty.[1] Their eldest son was a brilliant medical student, who, before he was twenty-one, was awarded the Aesculapian Society's first gold medal for an experimental research on pus, but unfortunately died from a dissecting wound the following year; the third son, the second Robert Waring Darwin, was, like his father, both a doctor of medicine and a Fellow of the Royal Society. He became the leading physician of Shropshire, accumulated a handsome fortune, and married Susannah Wedgwood, the eldest daughter of Josiah Wedgwood, F.R.S.[2] Their youngest son was Charles Robert Darwin, the celebrated naturalist. He married his cousin, Emma Wedgwood. Three of their sons and one grandson became eminent scientists and Fellows of the Royal Society.

Erasmus Darwin's second wife, the grandmother of Francis Galton, was Elizabeth Collier, widow of Edward Sacheverell Pole (a relative of the famous Dr. Sacheverell who was impeached in 1710). Here we seem to encounter a temperamental strain, differing still more widely from that which characterized the Galtons and the Barclays. This branch begins with two memorable scientists—Sir Henry Savile, tutor to Queen Elizabeth I, and founder of the Savilian professorships of Geometry and Astronomy at Oxford, and Sir William Sedley, founder of the Sedleian Chair in Natural Philosophy. Both were direct ancestors of Francis. Sedley's son John married Savile's only daughter Elizabeth. She was the precocious girl of whom the poet Waller wrote:

> Here lies the learned Savile's heir,
> So early wise and lasting fair
> That none, except her years they told,
> Thought her a child or thought her old.

among the Darwins before this point; it may have entered the stock through Erasmus's mother Elizabeth Hill, who was very probably a near relative of the botanist, Sir John Hill of Lincoln. As Galton remarked, when the Darwins display a scientific bent, it is biological rather than physical, technological, or mathematical. For the earlier Darwins see *The Pedigree of the Family of Darwin* (1888) by H. F. Burke, Somerset Herald, and E. Krause, *Erasmus Darwin* (1879).

[1] Of the Howards the most celebrated were the Dukes of Norfolk; the first Duke was created Earl Marshal (c. 1440), the second was grandfather of Anne Boleyn and great-grandfather of Queen Elizabeth I. Mary Howard's mother, Penelope Foley, was related directly or indirectly to many other noble families—the Beauchamps, the Devereux, and the Nevilles (each furnishing Earls of Warwick), the De Veres and the De Bohuns.

[2] Josiah Wedgwood, Charles Darwin's maternal grandfather (not mentioned by Pearson) was the famous potter who developed his celebrated ware mainly as a result of his scientific and experimental ingenuity. He was a man of much greater originality than any of the older Darwins. Susannah's brother, Thomas Wedgwood, published in 1802 a paper on 'Copying Paintings on Glass and Making Profiles, by the Agency of Light on Nitrate of Silver', and thus became one of the pioneers of photography: (see Eliza Meteyard, *The Life of Josiah Wedgwood*, 1865 and *A Group of Englishmen*, 1871). I should therefore be tempted to attribute the special characteristics of Charles Darwin's genius as much to the Wedgwood side of the family as to the Darwinian.

Their son was the playwright, Sir Charles Sedley, one of the most profligate of Charles II's courtiers, whose lewdness shocked even Pepys. His lyrics—" Phyllis is my only joy ", " Love still has something of the sea "—adorn almost every anthology. His only child was Catherine, Countess of Dorchester, who succeeded Arabella Churchill as mistress of James II. She was a woman of strong character, sprightly wit, and (if Kneller's portrait can be trusted) not without beauty.[1] She subsequently married David Colyear, a sagacious officer of foot, who served under William of Orange and was raised to the peerage as first Earl of Portmore. Their son, Beau Colyear, the second Earl of Portmore, married Juliana, Dowager Duchess of Leeds. The Duchess engaged a governess for her daughters; and it seems probable that her choice fell on a grand-child of Jeremy Collier, a man of high character and ability.[2] At all events a few years later Beau Colyear had by this governess a natural daughter named Elizabeth Collier, " a lady of great talent and natural charm "; and it was she who eventually became Erasmus Darwin's second wife. It must be, I fancy, to this particular strain in his ancestry that Francis Galton owed his lively humour, vivid imagination, and literary tastes and style, which so sharply distinguished him from the rest of the Galton and Darwin stock, as well as the wayward behaviour which, in his early youth, occasioned not a little anxiety in the mind of his somewhat Puritanical father.

From this brief survey of his pedigree it is plain that Francis was a mixture of many different breeds. The results are perhaps most obvious if we consider his physical build and appearance. Excellent portraits of his ancestors and other relatives still survive—many of them by artists like Reynolds, Raeborn, and Kneller.[3] From the Darwin side he seems to have inherited the brachycephalic skull, with the large and slightly sloping forehead, the flattened occiput, the overhanging brows, and the luxuriant eyebrows that so often go with them—all

[1] It was originally planned that she should marry the first Sir Winston Churchill; but she herself had loftier aspirations. Macaulay gives a lively account of her career and her fruitless manoeuvres to rescue James from the catastrophe which she foresaw (*History*, ch. VI). According to Macaulay (who quotes Charles II's jests and her own about her looks) her appearance, unlike her intelligence, was decidely homely; but this is hardly borne out by Kneller's portrait, even if we allow for an artist's flattery.

[2] He figures in our history books as the non-juror whose attack on Dryden, Congreve, and Wycherley, in his *Short View of the Profaneness and Immorality of the English Stage*, did much to cleanse the drama of those days. " There is hardly any book of that time," says Macaulay, " from which it would be possible to select specimens of writing so excellent and so varied."

[3] Pearson's plates reproduce over fifty. Most of them at the time he wrote were still at Claverdon in the possession of Mr. Wheler Galton. Several now hang in the National Portrait Gallery. To make a fair comparison one should examine not the plates, but the originals.

The development of post-Mendelian genetics has impressed on us our deplorable ignorance of the way human characteristics are transmitted, and particularly the wide gap that separates hypothetical genotype from observable phenotype. Hence the attempts at tracing the genealogy of a given individual's outstanding peculiarities, which were so popular at the beginning of the century, have long gone out of fashion. Nevertheless, where still accessible, such details seem well worth placing on record, in the hope it may eventually prove worth while taking up such speculations once again. In what follows I have tried to note more especially those features and characteristics of body build which Mendelian writers themselves have often held to be ' inherited as unit characters' (if I may borrow a succinct but somewhat misleading phrase).

of which are familiar from the portraits and busts of Charles Darwin, and are equally conspicuous in Erasmus and Robert Waring Darwin, and in Charles Darwin's own sons.[1] However, he did not inherit what the family called the 'Socratic Darwin nose' or the firm and slightly undershot Darwin chin (both of them well marked Wedgwood characteristics),[2] nor yet the heavy, stooping, somewhat clumsy body, which most of the male Darwins tended to develop after middle age. Francis's nose and face, particularly its lower part, were refined and delicate almost to effeminacy—a trait which seems to have entered the stock with Beau Colyear, and appears more or less intermittently in his descendants; it was obvious in the oldest brother Darwin Galton, and still more in his sister Bessie (Mrs. Galton Wheler[3]), both of whom had the same slightly prim expression about the lips that can be seen in later portraits of Francis.[4] Of his other distinctive traits his tall frame, fair hair, and blue eyes were attributed to the Barclay heritage; his strength and endurance to the Scottish elements—the Gordons and the Camerons. Longevity was particularly characteristic of the Barclays, Colliers, and Galtons; many lived to well over 90. The asthma and deafness which afflicted him in later life were typical Galtonian ailments.

It is tempting to speculate in much the same fashion about the sources of his intellectual and temperamental qualities. But, unlike so many bodily traits, mental tendencies show little or no discernible indication of unifactorial transmission. And in the Darwin-Galton pedigree almost the only mental characteristic we can confidently assign to hereditary endowment is the intellectual precocity and high intelligence which Francis showed even more conspicuously than

[1] Francis was examined by phrenologists on two or three occasions. While he was at King Edward's School one of the Cambridge examiners, an enthusiastic follower of Combe, asked to inspect the heads of the scholars in order that he might compare the results with the marks gained in the examination. So impressed was he by Francis's skull that he sent for him a second time. "This boy," he told the headmaster, "has the largest organ of causality I have ever seen, except in the case of Dr. Erasmus Darwin." "Why," replied Dr. Jeune, "he is Dr. Darwin's grandson."

[2] Charles Darwin's face (though not his skull), like those of several of his sisters and sons, shows a striking resemblance to the face of his mother, Susannah Wedgwood. I may add that, in common with other families of those days, both the Darwins and Galtons fondly discussed points of family resemblance or difference in their children, and sought to account for them by referring to their various ancestors. Francis himself took a keen interest in head shape and physiognomy, and later endeavoured to study them by more exact methods.

[3] Her face, in the portrait which depicts her at the age of 80 and formerly hung in Claverdon, might almost be mistaken for that of Francis. Seen side by side, as I saw them in later life, Francis and Darwin Galton were unmistakably brothers. Yet in appearance all three were quite unlike their father or mother. On the other hand, there is a striking resemblance between Francis and his uncle Sir Francis Sacheverel Darwin (grandson of Beau Colyear); and both were considered by family to resemble Catherine Sedley (the Countess of Dorchester) and Sedley the poet.

[4] Perhaps the best account of Galton's physical appearance in later life is that given by Mrs. Sydney Webb (later Lady Passfield). Among the many eminent scientists with whom she became acquainted, she says, "the one who stays in my mind as the ideal man of science is, not Huxley or Tyndall, Hooker or Lubbock, still less my guide, philosopher, and friend Herbert Spencer, but Francis Galton, whom I used to observe and listen to with rapt attention. Even today I can call up that tall figure, with its attitude of perfect physical and mental poise, the clean shaven face, the thin compressed mouth with its enigmatic smile, the long upper lip, prim chin, and, presiding over the whole personality, the prominent dark eyebrows, from beneath which gleamed, with penetrating humour, contemplative grey eyes" (*My Apprenticeship*, 1926, pp. 134–35).

the other members in this family tree. Terman assesses his I.Q. as approximately 200, and that of Charles Darwin, with less assurance, as between 135 and 140.[1] An exceptional measure of intelligence is traceable in one or more members of every one of the ten generations for whom we have first hand information —right back to the Sedleys and the Saviles of the 16th century. The steady ascent in social rank of the Galtons, the Barclays, and the Darwins, manifestly implies a degree of ability that must have been well above the general average, and suggests a cumulative process of social selection. The later generations include eleven Fellows of the Royal Society—surely a record. Francis himself was elected in 1856, and later was awarded the Gold Medal, the Society's Copley Medal, and in 1902 its Darwin Medal. Both his grandfathers[2] were Fellows, two of his cousins,[3] one of his uncles,[4] three of his nephews, and one great-nephew.[5]

To assign the nature and origin of his more specialized abilities would be a far more precarious venture. He was, like the Darwins, a man of science rather than a man of business or a man of letters; and, like his famous cousin, Charles, he displayed in an extraordinary degree what McDougall once described as " the exploratory and inquisitive disposition which characterizes so many of the world's inventors and discoverers ".[6] Yet, unlike his cousin, he appears also to have been endowed with a touch of the poetic imagination of the Sedleys, and a good share of their literary skill and humour, and (with several other members of the Galton family) a strong mechanical bent.[7] In the main, however, his mind (to use the familiar antithesis) was analytic rather than synthetic—highly

[1] As Sir Gavin de Beer has pointed out, " Darwin was a late developer —a peculiarity that was clearly a function of his genetic make-up because the same feature was characteristic of his brilliant children " (' Charles Darwin: A Master Mind ', *Proc. Brit. Acad.*, XLIV, 1958, p. 181). Throughout his later life indeed " the mills of his mind, like the mills of God, ground slowly "—and this was just as well, considering the mass of sifted evidence on which his great theory depended.

[2] Samuel Galton the Second, and Erasmus Darwin.

[3] Sir Douglas Galton, K.C.B., and Charles Darwin.

[4] Robert Waring Darwin.

[5] Sir George, Sir Francis, and Sir Horace Darwin, Sir Charles Galton Darwin, son of Sir Horace (Professor of Natural Philosophy at Edinburgh and later Director of the National Physical Laboratory). The eleventh Fellow in my list is Josiah Wedgwood, Charles Darwin's maternal grandfather, who was not directly related to Galton.

[6] Dr. Eliot Slater describes both Darwin and Galton as showing a " compulsive curiosity " and the Galton family as exhibiting an " obsessional desire to count or classify " (' Galton's Heritage ', *Eugen. Rev.*, LII, 1960, pp. 91f.). Psychiatrists are prone to express the exceptional manifestation of any common characteristic by a pathological epithet. If we discount the psychoneurotic implications, we may, I think, accept both descriptions. Darwin in one of his letters relates how he has been speculating about the characteristics which make for originality or creativity—or, in his own words, " what makes a man a discoverer of undiscovered things ": it consists, he thinks, " in habitually searching for the causes and meaning of everything " and " implies (amongst other things) sharp observations ".

[7] Darwin, it may be recalled, declared that during his life he had been " singularly incapable of learning any language "—a marked contrast to Galton. " Versification," he adds, " I could never do well." On the other hand, even before he was eight, his " taste for natural history, especially for collecting, was very strong and clearly innate " (*Autobiography*, pp. 2f.)

Galton's literary skill is seen best in his youthful writings; but even in his old age his sense of style is revealed by his comments on contemporary scientific writing. The Cambridge enthusiasts curious, highly critical, tending not merely to observe details, but to classify and organize the details into a rational scheme; and with this went the peculiar fondness for counting and calculating which (as we have noted) seems to have been an almost obsessive propensity in several of the Galtons. He certainly inherited much of their remarkable energy and persistence. Yet in temperament he differed widely from his parents and from most of his surviving brothers and sisters. He was, as the family frankly observed, " decidedly restless "—displaying even up to middle age the *Wanderlust* and love of change that had been characteristic of so many of his Scottish ancestors. It is perhaps to this constitutional restlessness that he owes his amazing versatility. The industry, the extreme conscientiousness, and the businesslike habits—the distinctive characteristics of his father and indeed of so many eminent Quakers—were, I fancy, rather painfully acquired during his upbringing, and not, as Pearson supposes, literally inherited.

II. Childhood and Education

Francis was the little Benjamin of his family—the last of nine children. Of the others the youngest boy was already seven and the youngest girl already eleven when he was born, so that within the family he had no playmates of his own age. " He was," says Mrs. Galton Wheler (the oldest of the lot), " the pet of us all "—a circumstance that may account for several traits that he exhibited as he grew older. His sister Adèle, who, owing to a curvature of the spine, was something of an invalid, devoted her time to his early studies. " She made him learn his letters in play, and he was able to point to each before he could speak " (I am again quoting Mrs. Galton Wheler); " and she taught herself Latin and Greek so that she might teach him." By the time he was 2½ he could read simple fairy tales; and he could sign his name before he was 3. The following is the first of many letters treasured by the family.

" My dear Adèle, I am four years old, and I can read any English book. I can say all the Latin substantives, adjectives and active verbs, besides fifty-two

who today are so eager to " bridge the two cultures " might well refer to Galton's paper on ' Suggestions for Improving the Literary Style of Scientific Memoirs ' (*Trans. Roy. Soc. Lit.*, XXVIII, pp. 1–8). Here he criticizes in some detail " the comparative rarity among the English of a sense of the difference between good style and bad, especially noticeable among younger scientific men whose education has had little concern with the Humanities ".

Dr. Slater very justly notes the fact that, despite his ' feminine streak ' and ' acute sensibilities ', Galton seems to have been almost wholly devoid of aesthetic interests: " art, whether in colour or form, was no essential need for him "; he was " totally unmusical ", and during his travels quite " unimpressed by the magnificent scenery ". I fancy Galton himself has provided the clue. " Nearly every Quaker is descended from men and women who dressed in drabs; and one of their strongest opinions was that the fine arts were worldly snares: a born artist could never consent to separate himself from his fellows on such grounds ", and would therefore have " deserted ". This process, he thinks, may have been responsible for the Quaker's lack of " the temperament associated with a love for colour ", and incidentally for the well-established fact that colour-blindness is " nearly twice as prevalent among Quakers as among the rest of the community ". Dalton, who discovered colour-blindness as a personal peculiarity of his own, was " a Quaker to his death "; Young, who became greatly interested in the study of colour, ceased to belong to the sect (*Human Faculty*, pp. 32f.).

lines of Latin poetry. I can cast up any sum in addition and multiply by 2, 3, 4, 5, 6, 7, 8, (9), 10, (11). I read French a little and I know the clock. Francis Galton. Feb(r)uary 15, 1827. "[1]

When he was five, he went to a kindergarten school; and one afternoon the maid who went to fetch him discovered him holding a handful of youngsters at bay, and shouting

" Come one, come all! This rock shall fly
From its firm base as soon as I."

An aunt who visited the family when he was six describes him as " a little prodigy, reading Pope and Shakespeare for pleasure. He has only to go over a page a couple of times and he can repeat it by heart." The next year he was studying Greek; and, when an academic friend kept quizzing him about Homer's *Odyssey*, Francis at length replied, " Pray, Mr. Horner[2], look at the last line in the twelfth book." The last line (as Lang translates it) reads: "All this I have told thee already, and it likes me not to repeat a twice-told tale."

On his eighth birthday, when he was sent off to a school at Boulogne, he drew up a semi-humorous ' Last Will and Testament ' bequeathing " to my dearest sister Adèle my Watch, my English books, and Collection of Beetles; . . . to Bessy my Minerals and Shells; to Lucy my Hygrometer; to Darwin my parchment; to Erasmus my Bow, Arrows, and Steel Pens . . . And I make my dearest sister Adèle my executrix. Signed, sealed and delivered " . . . etc. The items quoted display his early interests. In his new school he was placed in one of the highest classes, with boys ranging in age up to 15. Both his father and his various masters recognized that he was a lad of great ability; but none of them recognized *how* great it was. From the last of the two later schools to which he was sent, King Edward's School, Birmingham, he wrote several letters to his father and sister, begging them to arrange for him to do work of a higher and broader type, following up the algebra and geometry, the dynamics and the chemistry, the history and the English poetry that he had studied at home. " I am not getting on in the least," he complains, " Every day is a day wasted . . . Only six books of Euclid is not much for two years." He expressed the same regrets when he came to write his *Memories*. " The time spent there," he writes, " was a period of stagnation: I learnt nothing, and chafed at the limitations. I craved for an abundance of good reading, solid science, and well taught mathematics."[3]

[1] The ' 9 ' has been erased and the ' 11 ' has a slip of paper gummed over it; it is not clear who corrected the spelling of the month.

[2] The visitor was Leonard Horner, the first Secretary (or rather ' Warden ' as he preferred to be called) of University College. According to the College records his professorial colleagues reacted to his " persistent intermeddling " much in the same way as little Francis, though not so speedily or effectively.

[3] Darwin said much the same of his time at " Dr. Butler's great school at Shrewsbury ", a school now so proud of his name. " Nothing could have been worse for the development of my mind, for it was strictly classical: the school as a means of education was to me simply a blank." The accounts of both of them remind one of Osbert Sitwell's entry in *Who's Who*, under the heading of ' Education ': " During the holidays from Eton."

His mother earnestly desired that, since the family business had been wound up, Francis, like her famous father and her brothers, should become a doctor. Accordingly, an uncle by marriage (Dr. Booth) agreed to sponsor his entrance as a House Pupil at the General Hospital, Birmingham, " at the rate of 200 guineas per annum ". And so, after spending a week in London with Charles Darwin for Queen Victoria's coronation, and then making a holiday trip on the Continent with another young medico, he started at the age of sixteen to " go the round of the wards with the surgeons and physicians ". " I begin to understand all the humbug of medicine, which is not a little! ", he writes a few weeks later. " Doctors have the fault of parsons—of being much too positive . . . Cut a brace of fingers off yesterday, and one the day before. Happy to operate on any one at home! "

The following year, however, he was again in London attending medical lectures at King's College. There he found the laboratory work, and particularly the ' legal logic ' of forensic medicine, far more congenial than dispensing pills or drawing out teeth. " It had " (he says in his *Memories*) " a sort of Sherlock Holmes fascination." At the examination he took second place, and was "much vexed at not being first". But, he adds, now he has " spoken to Charles Darwin about Cambridge, who recommends going there next October, and to read mathematics like a house on fire . . . They (mathematics) are exceedingly interwoven with chemical and medical phenomena." In the meantime he asks permission to spend the summer vacation with another student " at Giessen, the laboratory of Liebig the first chemist in the world." Once there, however, he was seized (" like a migratory bird ", as he afterwards said) with a passion for travel; and he writes to his father that he has resolved " to make a bolt down the Danube and see Athens and Constantinople "—a courageous decision in those days for a lad of only eighteen.[1]

In October 1840 Francis and his father arrived on the top of a stage coach before the famous gateway of Trinity College, Cambridge. Cambridge in those days could boast neither a Natural nor a Moral Science Tripos. Since he had chosen Mathematics, his tutor set him, " with a sort of grin ", to study Conic Sections. The daily time-table he found pretty strenuous. " Up for Chapel at 7," he says in the first letter written after he had settled down; " Lectures 2 hours a day; Reading (full tide) 10½ hours—really too much." To stimulate the flagging brain, he explains, he had invented a ' Gumption-Reviver '; and a sketch of the apparatus is appended. It depicts a kind of gallows supporting a funnel of water that drips on to a napkin enveloping the student's drooping head; the flow has to increase with time, for, " as the hours of study increase in

[1] " From the age of nine ", he says, " I had saturated myself with Byron's poetry, which gave me a longing to see the East." His original plan had been to pass the summer shooting reindeer in Lapland; the itinerary he worked out would have followed a route known only to the reindeer hunters themselves. This was very wisely turned down by his parents. Much of the journey down the Danube was made in a small rowboat, accompanied only by his English companion, an aged Austrian, and a boy, toiling at the oars by night and day.

arithmetic ratio, so the weariness increases in geometric ratio: unfortunately some of the water has splashed on to my notepaper."[1]

Of the surviving manuscripts relating to this period, one, dated 1841, includes a long poem, headed with the motto *Tu Marcellus Eris*, which celebrates the birth of Edward, the future Edward VII, and traces the baby's descent from Edward II, the first prince of Wales:

How different is thy lot to Edward's son
Born in the land his sire had scarcely won,
'Midst warriors rude within that turret tall
That beetles o'er Carnarvon's massive wall.

It was presumably composed for the Chancellor's Medal, obtained in that year by one of Galton's closest friends, H. S. Maine.[2] In the end, however, Galton found the work for an Honours degree in Mathematics at once too exacting and too dull. His health suffered, and so, like Charles Darwin, he eventually contented himself with a Poll degree.[3]

III. Travel and Exploration

Early Scientific Work. Galton's adult life may be divided into three main periods; during the first (1844–1864) he was chiefly occupied with travel and exploration, and with various geographical and meteorological studies arising out of his adventures; during the second (1865–1899) he became more and more engrossed in the theoretical study of individual differences, with the problems of inheritance as the focus of almost all his researches; during the third (1900–1911) his interest changed to the more practical aspects of the subject, and he came forward as the champion of eugenics.

[1] His letters to his father are continually illustrated by ingenious mechanical designs, some imaginary, some actually constructed—for instance, a ' patent lamp ', and an ' unpickable lock '. The latter he demonstrated to the representative of a famous firm of safe-makers; when his visitor extolled an elaborate lock made by his firm, Galton at once showed how it could be picked with the help of a set of knitting needles of various sizes—a procedure which (so he facetiously declared) he meant to patent " For the Use of Thieves, House-breakers, and Others ". The earliest of his many mechanical devices, dated July 1835 (when he was only 13), is entitled " Francis Galton's Aerostatic Project ": it was apparently a flying machine with flapping wings to be worked by an oscillating steam-engine. One of his most ambitious inventions was a printing telegraph, designed ten years later (about 1845) as a result of a number of extensive experiments—the first instrument of its kind so far as I am aware (*The Teletype*: *A Printing Electric Telegraph*, by Francis Galton, M.A., John Weale, 1859, pp. 32). Whether the complete instrument was ever manufactured is unknown; but it appears to have interested one or two of the commercial companies that had recently introduced telegraphy into this country. The Eugenics Laboratory contains numerous bits of mechanism and mechanical contrivances, the purpose of which has long been forgotten.

[2] One of the most gifted scholars produced by Christ's Hospital, who afterward, as Sir Henry Sumner Maine, gained great celebrity as a student of primitive custom and law.

[3] In the examination, so he tells his father, " classics was below par; as for medicine, etc., I was only allowed a month to get my subjects up; in Mathematics I was third, and would have been first but for misunderstanding one question ". (This period of Galton's life, and particularly the influence of his medical studies on his later psychological investigations, has been more fully discussed in Dr. Charlotte Banks' paper, presented at the last meeting of the British Association and appearing in a forthcoming issue of the *British Journal of Educational Psychology*.)

In October, 1844, the year in which Francis left Cambridge, his father, Tertius Galton, died. Released from the rigorous Quaker supervision, which hitherto had regulated almost every step, he seems to have experienced a sharp reaction. " I was free," he wrote later on, " and eagerly desired a complete change. Besides I had many wild oats to sow . . . So, finding I had a competent fortune, and disheartened by the sense that medical knowledge was so lax and progress apparently barred, I determined to give up a medical career. My passion was for movement and travel." The following year he set out quite alone for Egypt and the Sudan. There one of the Beys said to him: " Why follow the usual routine of going only to the Second Cataract? Cross the desert and see Khartoum." And so he did. For a while (he tells us) he " lived a very oriental life ", dressed in Arab costume, and became "fairly fluent in Arabic". After a succession of adventures and the death of his devoted servant Ali, he at length worked his way home via Jerusalem and the Holy Land, " escorted by mounted spearmen, and bringing back a couple of monkeys ".

On his return to Claverdon, whither his mother and sister had retired, he appears at first to have thought of settling down, like his elder brother, Darwin Galton, to the life of a sporting country gentleman.[1] On his brother's advice he joined the Leamington ' Hunt-Club ', and the next four or five years were passed in hunting and shooting with a set of wealthy young men from Warwickshire, noted for their recklessness and extravagance. The attractions of gambling, which ruined a good many of them, he managed to resist by " viewing it in the light of mathematical reasoning." His most exciting experience appears to have been an ascent by night in a balloon from Cremorne Gardens with an aeronaut and a boy, landing miles away on the lawn of an irate squire.

Galton's next expedition, to tropical South Africa, had a more serious purpose. In those days the exploration of ' darkest Africa ' had much of the fascination that the exploration of ' outer space ' possesses today. Soon after the independence of the Transvaal had been formally recognized, the neighbouring territory of Bechuanaland, which had been opened up by missionaries from the Cape like Moffat and Livingstone, began to assume international importance. But of the territory on the opposite side of Bechuanaland, between the Kalahari Desert and the West Coast, practically nothing was known. This Galton determined to explore, starting from Walfish Bay. As his travelling companion he engaged a young Swede named Anderson, who had been brought up by an English Quaker.

[1] See *Memories*, ch. VIII (' Hunting and Shooting '). In Victorian Warwickshire, as I can testify from my own recollections, there was a sharp distinction between social classes; the ' gentry ' as they were called (i.e. members of the older county families, like the Dugdales, or of the ancient aristocracy, like the Warwicks and their circle) resented any intrusion from those connected with ' trade ' (such as the rich industrialists from Birmingham). However, in the second or third generation the younger members, still a little ashamed of their commercial origins, often succeeded, usually by going first to one of the older universities and then dropping into the role of landed proprietors, in winning a tardy acceptance. The Galtons were typical instances of this particular form of ' social mobility '. Later on it became one of Francis Galton's most cherished aims to substitute a genuine ' meritocracy ' for the ' relatively decadent aristocracy of birth '.

They found the country sparsely populated with four very different tribes—the Namaquas, ' a superior Hottentot race living on the edge ', the pastoral but warlike Bantus in Damaraland, small yellow Bushmen in less fertile parts of the lowlands, and a fugitive Negro race on the hills—each of whom provided Galton with numerous problems in comparative anthropology.[1] Owing to the inhospitable nature of the region, they ran short of supplies. Then lions killed a mule and a horse: the carcases they recovered and used as food. Galton succeeded in making friends with the " murderous Damaras " by investing a chieftain with a theatrical crown " bought in Drury Lane for some such purpose "; and eventually the party worked their way for more than 1,000 miles inland " through a country never before penetrated by a civilized being ".[2] On their return a detailed account of the journey and a valuable survey of the area was published, with maps and woodcuts based on Galton's sketches.[3]

The following year, 1853, Galton married Louisa Butler, daughter of the Dean of Peterborough and former headmaster of Harrow, sister of a still more famous headmaster of Harrow, who subsequently became Master of Trinity College, Cambridge. After his marriage Galton's travels virtually ceased: otherwise it might have been Galton, and not Stanley, who set out to discover Livingstone. In 1856, however, as Secretary of the Geographical Society, he drafted the instructions for the Burton-Speke Expedition from the East Coast, which led to the discovery of Lake Tanganyika and Lake Victoria Nyanza.[4] Meanwhile, he himself set about compiling ' Hints to Travellers ' and charts of the local climate to aid later explorers.[5] These were followed by meteorological

[1] See *Human Faculty*, pp. 200f., and various papers in the *Journal of the Anthropological Institute*.

[2] *The Times*, quoting the address of the President of the Society (Sir Robert Murchison) on Galton's return: we are told that the " astronomical observations determining latitudes and longitudes were made most accurately by Mr. Galton himself ".

[3] *The Narrative of an Explorer in Tropical South Africa* (1853, 2nd ed. 1889). Galton was awarded the gold medal of the Royal Geographical Society, and in the following year the silver medal of the French Geographical Society. After 1884, when it was annexed by Bismarck, till 1920, the region was known as German South-West Africa.

[4] According to Ptolemy, a Greek merchant named Diogenes returning from India, somewhere about the middle of the first century, landed on the African coast near Zanzibar, and claimed " after passing snow-capped mountains" (the so-called 'Mountains of the Moon', i.e., Mount Kenya and Mount Kilimanjaro) " to have reached the vicinity of two great lakes from which the Nile draws its twin sources ". In the early 1850's Arab slave-traders reported similar stories related by the natives. The Royal Geographical Society was sceptical: how could snow exist so near the Equator? To answer these questions a special expedition was planned. As the man who at that date knew as much as anyone about the problems of African travel, Galton was strongly urged to undertake it. But he was still suffering from a malarial infection caught during his earlier travels. In Kensington Gardens there is a solitary red obelisk dedicated to the memory of Speke. Galton later urged that the memorial should be extended to commemorate still more famous names—Burton, Livingstone, Stanley, Baker, and Grant. Surely Galton's own name might with justice be included.

[5] These were followed in 1855 by *The Art of Travel*, a guide for explorers. Here incidentally he relates an occurrence which admirably illustrates what later became his ruling maxim—' Whenever you can, measure or count '. In Damaraland he met a typical Hottentot Venus whose buttocks were so immense that he felt they should be accurately measured. Yet any such approach was found

charts for the British Isles—the first weather maps ever to be published. And on April 1, 1875, the readers of *The Times* began to see at their breakfast tables diagrammatic maps with isobars and the like, very much in the form with which we are familiar today. It is to Galton and to his meteorological studies that we owe the name and the whole notion of the anticyclone. Had he done nothing else, he would still have deserved fame as an early pioneer in the science of meteorology.[1]

IV. Psychological Studies

Galton's observations made during his travels began more and more to turn his thoughts from man's environment to man himself. "Before the appearance of Darwin's *Origin of Species* in 1859," he tells us, "I had already begun to interest myself in the human side of geography. Some ideas I had about human heredity were set fermenting; and I then began a book on *Hereditary Genius*." The leading ideas were embodied in a preliminary paper entitled "Hereditary Talent and Character", published in *Macmillan's Magazine* in 1865. The wording of the title is significant. "The terms talent and character," he says, "are exhaustive; they are meant to include the whole of man's spiritual nature." In writing *Hereditary Genius*,[2] however, he appears to have preferred a tripartite to a dual classification of mental characteristics. He now speaks of three main ingredients—the ability to work, an interest in the work, and the power or will to work, corresponding to what Ward and Stout would have called the cognitive, the affective, and the conative aspects of mental activity. It is principally with the first—with ability or talent in its various forms—that his book is concerned.

And here he introduces at the very outset a new and far-reaching distinction —the distinction between *general* ability and *special* abilities. The current

to be misinterpreted. He resolved his dilemma by the device employed by Gulliver's Laputan tailor: "with the aid of navigational instruments" he measured the lady's dimensions "from a distance".

[1] See his papers on 'Meteorological Charts' (*Phil. Mag.*, 1861) and on 'A Development of the Theory of Cyclones' (*Proc. Roy. Soc.*, XII, 1862, pp. 385f.). Since the general theory as he developed it envisaged vertical movements of the air as well as horizontal, he pressed strongly for studies of the upper atmosphere by means of unmanned balloons, the firing of guns and rockets, and other experimental devices which have become a commonplace today. From 1860 or earlier until 1901 (when deafness forced him to retire), Galton, in addition to his other work, was actively engaged in meteorological studies as a member of the new Meteorological Committee, and as a chairman of the Kew Observatory. Several papers written about this time deal with unexpectedly topical problems—e.g., a plan for a decimal coinage (10 mites=1 cent; 10 cents=1 florin; 10 florins=1 pound), and a scheme for interstellar communication, by broadcasting mathematical formulae (such ratios as π, $\sqrt{2}$, etc.), and so building up a code for concrete and abstract ideas. See more particularly *Memories*, chap. XVI.

[2] 1869. A cheap edition (1962, 8*s*. 6*d*.) with an introduction by Professor Darlington is now available in Collins' Fontana Library.

faculty psychology recognized only the latter.[1] Galton insists on the superior importance of the former, a doctrine borrowed later on by both Binet and Spearman. " Numerous instances recorded in this book," he says, " show in how small a degree eminence can be considered as due to purely special powers. People lay too much stress on apparent specialities, thinking that because a man is devoted to some particular pursuit he would not have succeeded in anything else. They might as well say that, because a youth has fallen in love with a brunette, he could not possibly have fallen in love with a blonde. As likely as not the affair was mainly or wholly due to a general amorousness." It is just the same, he argues, with mental exploits. And accordingly what he chiefly proposes to discuss is the inheritance of general ability.

Other writers in the past had, of course, considered the possibility that genius might be inherited, some defending the notion, others attacking it. Galton himself, however, claims to be " the first to treat the subject in a statistical manner and to arrive at exact numerical results ". In the preliminary discussion he begins by suggesting that people can be graded for ability in accordance with the normal distribution; and here, for the first time, we find this famous curve applied to mental differences. He proposes to divide the entire range into eighteen classes, and makes the subdivisions between each approximately equal to the so-called ' probable error '. The term ' genius ' is defined as covering the top three classes, that is to say, the brightest 248 in a million: thus very roughly a genius is the ablest person in a random sample of 4,000. He points out that, since the distribution is symmetrical, the same principles could be used to define imbeciles and idiots; and for these he uses a method of assessment which anticipates the ' mental ratio ' or I.Q. A person in the lowest grade of deficiency, he says, is roughly capable of working with the efficiency of one-third of an average man; a person in the next higher grade of working like two-thirds of a man.

To demonstrate his theory of inheritance Galton examines the pedigrees of nearly a thousand geniuses—judges, generals, statesmen, scientists, poets, painters, and divines. Among their relatives he discovers 89 equally eminent fathers, 114 eminent brothers, and 129 eminent sons. If for simplicity we suppose that the number of male children born to each member of the population, whether a genius or not, is on an average four, then the chances that the son of a genius will himself be a genius would be 129 times as great as that of a parent chosen at random; and, since four is obviously much too high a figure, our estimate of the chances must be much too low. Galton, of course, was well aware that the environmental advantages which an able father could provide for his children might well be partly responsible; and both in this book and in later papers he deals at some length, though not perhaps convincingly, with this complication.

[1] The doctrine itself, however, is at least as old as Aristotle; and it might certainly be read into St. Paul's adaptation of Menenius Agrippa's fable of the body and its members (*Livy*, II, 32) and his statement that " there are varieties of gifts, but one pneuma " (i *Cor.* XII, 4; this chapter is perhaps more frequently quoted in Quaker literature than any other from St. Paul).

The ideas and methods outlined in *Hereditary Genius* were applied to a more specialized problem in his book on *English Men of Science: Their Nature and Nurture* (1874). Today in view of the current demand for scientists some of his conclusions are still well worth studying. From his inquiries he calculated that there were in the British Isles about 300 males between the ages of 50 and 65 who had achieved recognition as men of the highest scientific ability, but that this was well below the number we might expect on the assumption of a normal distribution of ability. Now there exists, so he argues, an immense deal of national work which none but men of scientific culture are qualified to undertake. " What qualities then ought we to look for in those who should be encouraged to take up science? " Some light, he believes, may be gained in analysing the qualities possessed by those who have actually achieved recognition. On the basis of questionaires addressed to 180 men of science, chiefly Fellows of the Royal Society, he enumerates the following special characteristics, in addition to a high degree of general ability: (1) Physical and Mental Energy, (2) Health, (3) Perseverance, (4) Business Habits, (5) Memory, (6) Independence of Character, (7) Mechanical Aptitude. These, it will be noted, are all characteristics which Galton himself exhibited in a signal degree.[1]

Of all his books, however, the one of greatest interest to the student of psychology is that published in 1883 under the title *Inquiries into Human Faculty and its Development.* Here Galton begins by emphasizing the wide extent of individual differences. " The moral and intellectual wealth of a nation," he maintains, " consists largely in the multifarious variety of the gifts of the men who compose it ": the endeavour to level them all to an identical pattern would be " the reverse of an improvement " and in any case would be doomed to fail. After a brief discussion of bodily measurements and of the influence of hereditary and environmental conditions on bodily height and health, he proceeds to summarize the main results of the relevant experimental and statistical investigations which he himself had already carried out on individual differences in various mental and moral ' faculties '.

We then reach what is really the central problem of the whole book—the analysis of individual personality as the joint effect of two distinct but complementary factors, ' Nature ' and ' Nurture '.[2] " Man," says Galton, " is so educable an animal that it is difficult to distinguish between that which has been acquired through education and circumstance, and that which formed the original grain of his constitution. Different aspects of his multifarious character respond to different calls from without . . . The same nation may be seized by

[1] There is now a good deal of evidence to show that the assumption of a strictly normal distribution leads to an underestimation of the numbers showing marked deviations in either direction. Ability, like stature, is almost certainly influenced by relatively rare ' major genes ' which are responsible for large effects (usually, but not always, in the downward direction) as well as by so-called ' polygenes ', which produce small but cumulative effects, and obey the familiar laws of multifactorial inheritance.

[2] The phrase is not, as a recent critic supposes, " an alliterative antithesis of Galton's coining ", but borrowed from Shakespeare (*Tempest,* IV, i, 188–9).

military fervour at one period, and by a commercial at another; the love of art or of science, of religion or of gaiety and adventure, may be paramount at different times." In short, " the interaction between nature and circumstance is so close that it is difficult to distinguish them with precision ".

The safest mode of approach, he believes, is to start by examining the more important ways in which post-natal experience operates, in other words, the effects of ' Nurture '. This he treats under two main headings as consisting of *ideas* and of the *associations* that introduce or suggest them. Ideas, he maintains, are conveyed by means of mental ' images '. At first sight this seems scarcely possible in the case of abstract ideas. But Galton argues that an " *abstract* idea is essentially a *cumulative* idea "—i.e. a kind of ' generic image ', analogous to the ' generic portraits ' that he had obtained by means of ' composite photography '. He is, however, far more interested in the different types of ' concrete images '.[1] These he had investigated in considerable detail by means of his well known questionaire; and a large part of the book consists of a systematic survey of the unexpected results so obtained. As he rightly points out, the whole inquiry reveals, perhaps more clearly than any other, startling differences between the mental processes of different individuals. And he goes on to indicate the practical values of such studies both for educational and for vocational guidance.

In these and many other investigations he repeatedly stresses the value of controlled introspection, and adduces a number of instances to show that by its means we can discover numerous illuminating facts which would never have been suspected had we restricted ourselves to the mere observation of outward behaviour. The information gained in this way, he says, often accounts for conduct that would otherwise be wholly inexplicable: for example, he notes with astonishment how completely devoid of visual imagery many highly educated persons prove to be, particularly scientists. On the other hand, perfectly normal people whom he encountered often experienced images of such hallucinatory vividness that they mistook them for actual perceptions. And almost invariably the two types of person—the extreme visualizers and the extreme non-visualizers —took it for granted that their own type of mentality was universal. Introspection alone reveals how widely, in cases such as these, the mental processes of different individuals differ from one another.[2]

[1] ' Generic images ' are more fully described in an appendix, which is abridged from a paper published four years previously. In the text the discussion of concrete imagery, number forms, colour associations, etc., is to be found (somewhat out of place, I fancy) just before the general discussion of nature and nurture. Fechner had already published introspective reports on the visual imagery of several of his subjects, and had briefly analysed their distinctive characteristics, mainly in relation to after-images (*Elements der Psychophysik*, 1860, II, pp. 469f.). Galton's research is noteworthy because of his use (i) of a standardized questionaire and (ii) of a rating-scale (based on an ' ogival ', i.e. cumulative normal, curve) to assess differences for which no direct mode of measurement is available—devices which were rapidly taken up by later psychologists.

[2] Part of Galton's research included an inquiry which in some respects anticipated the ' Census of Hallucinations ' carried out a little later by the Society for Psychical Research. The problem was apparently suggested by a couple of personal experiences related to him in confidence by Sir Risdon Bennett, F.R.S. (the eminently sane and matter-of-fact President of the Royal College of

However, in thus attempting to discover by means of inner observation how our own minds work, we are baulked, he says, by a special difficulty: "It would seem almost impossible to give the required attention to the processes of thinking, and yet go on thinking as freely as if the mind were in no way pre-occupied." Nevertheless he believes that in some of his experiments he "succeeded in evading this difficulty". Thus in his study of 'associations' he employs an ingenious procedure (what textbooks now call 'the method of free association') which "enables us to drag into light thoughts, ideas, and wishes that have lapsed out of ordinary consciousness", and so helps us to unravel the associative processes by which they have been acquired. Once again he gives detailed results from experiments upon himself and others, which he analyses statistically.[1] He makes a systematic comparison of the dates at which the associations so disclosed were apparently formed. Of the associations that occur most frequently (that is, at least three or four times), the majority, he finds, are drawn from childhood, and comparatively few from recent experiences. To interpret his results he suggests that we may think of the mind as divided into two or three fairly distinct compartments according to the degree to which the activities taking place are "lit up by consciousness". "There seems to be," he writes, "a presence-chamber where full consciousness holds court, and an antechamber just outside, crowded with ideas lying beyond the ken of

Physicians), who on two occasions saw a man in mediaeval costume enter his study and then vanish. Galton notes the various ways in which such 'visions' are usually distinguished from exceptionally realistic 'visualizations' (e.g. by their sudden, involuntary, or unexpected appearance, their abrupt disappearance, and 'an indescribable difference in quality'). He was surprised to find how frequent they were, not only in the sane, but more particularly in the eminent or gifted. The 'faculty', he believes, is commoner in childhood, but owing to repression tends to atrophy. "Let the tide of opinion change and grow more favourable to supernaturalism, and seers of visions will come once again to the front." In view of the recent renewal of interest in "spontaneous paranormal phenomena" the whole inquiry is well worth re-studying and perhaps repeating. Another type of 'vision', which many of his subjects (including Karl Pearson) described, consisted of what he called 'phantasmagoria'—shifting patterns, changing faces, scenic panoramas, filmy sheets of printed or tabular matter, quite vivid and yet unreadable—seen perhaps as hypnagogic imagery, but also quite often during the day usually when the eyes are closed. This too deserves renewed attention, particularly in relation to other indications of spontaneous cerebral activity.

[1] One of his incidental discoveries was the possibility of what was later termed 'imageless thought'. The problem of 'abstract' (or, as Galton preferred to say, 'generic') ideas had long been the subject of discussion among English philosophers. At the time Galton started his experiments the accepted view had been stated very succinctly by Burke, who contended that "when a word is unaccompanied by an image, there can be no notion in the mind". Max Müller argued that, although *some* sort of image was essential, the image of the word alone could carry thought. Galton replied that his own experiments demonstrated that *no* kind of image was absolutely necessary. A thought could be carried by what he described as a 'mental attitude' (cf. 'Thoughts without Words', *Nature*, 1887). Later he commenced a series of ingenious experiments in which he showed that even arithmetical thinking could be accurately performed "solely by imagined scents": e.g., if two whiffs of peppermint are associated with one of camphor, and three whiffs of peppermint are associated with one of carbolic, how many whiffs of camphor are suggested by two of carbolic? In working out such sums he decided whether they should be addition or subtraction by taking up 'the appropriate mental attitude' ('Arithmetic by Smell', *Psychol. Rev.*, 1894). Stout, who acted as subject in some of these experiments, fully endorsed the psychological conclusions thus inferred, and translated Galton's tentative hypothesis into terms of his own doctrine of 'implicit apprehension' (*Analytic Psychology*, 1896, I, pp. 85f.).

consciousness; out of this antechamber the ideas most nearly allied to the problem at issue appear to be summoned in a mechanical or a logical way, and so have their turn of audience." Beyond or below all this there is a darker basement, an underground storehouse from which older and remoter ideas can with greater difficulty be hauled up into consciousness. In all this we detect a remarkable anticipation of the theories and methods adopted later on by psycho-analysts like Freud and Jung.[1]

Galton applies the same hypothesis to account for the achievements of genius. The creativity of successful thinkers—great orators, imaginative writers, and inventive scientists—arises largely from the interplay of their conscious and unconscious processes: a flood of relevant ideas is always flowing through the channels of their fertile minds, usually without deliberate exertion or control; and the associations that bring the right idea at the right moment to explicit utterance operate like some curiously logical sorting machine. When they lack this automatic means of selection, such persons are likely to exhibit the phenomena of ' morbid imagination ' so characteristic of the neurotic and the insane. The ability to produce this rich flow of ideas he terms ' fluency '—a specific type of ability, which, it may be remembered, Spearman and many of his research students later on subjected to systematic investigation.

One or two further studies of what Galton termed ' morbid imagination ' may be mentioned, since they illustrate the daring way in which he sought to combine introspective with experimental techniques. In the hope of gaining some insight into the way the fantasies of the insane are built up, he determined, during the course of a morning's walk, to invest everything he encountered with the attribute of a secret spy. The experiment was only too successful. By the time he had reached Piccadilly, he says, " every horse on every cab-stand seemed to be watching me either openly or in disguise". These persecutory delusions, self-induced, lasted for eight or nine hours, and could be very easily revived, even two or three months later. On another occasion he hung up a picture of Mr. Punch, and treated it as a kind of fetish or idol, mentally ascribing to it all sorts of divine and magical powers. At first these daily rites had no effect, but presently he found himself behaving as though his self-imposed fancies were literally true. An ever-present image stamped itself upon his mind; and round

[1] A year or two later he developed these ideas still further in the last of his introspective experiments—a study of the influence of involuntary or unconscious processes on voluntary action. Here he drew special attention to the effects of the mental conflict or repression which often operates beneath the surface of ordinary consciousness. There seems to be, he said, a kind of struggle between two ' Egos '. " The self is by no means one and indivisible. . . Those who study the genesis of dreams will discover plain causes for thoughts that seem to have arisen spontaneously; for the imagination works in obscure depths out of the usual ken of consciousness " (' Free Will: Observations and Inferences.' *Mind*, IX, 1884, pp. 406–13). Finally, let me commend to those behaviourists who doubt the value of introspection the following remarks, as well as the evidence on which they are based: " Although philosophers may have written to show the impossibility of discovering what goes on in the minds of others, I maintain the opposite opinion. I do not see why the report of a person on his own mind should not be as trustworthy as that of a traveller in a new country whose landscapes are quite different to anything that we ourselves have seen " (*Nature*, Jan. 15, 1880, p. 256).

it were gathered a set of potent emotional associations—all utterly irrational. For weeks after the experiment was over, he still retained a deep and awe-struck reverence for Punch's grotesque figure.

Galton ends his discussion of the effects of association by describing the various ways in which young children seem to acquire their ' early sentiments '—how they start imbibing the likes and dislikes of their parents, and later tend to assimilate first their teachers' views, then the attitude and outlook of their social class and the religion of those around them, and with it the implicit moral ideals that make up what is popularly called 'conscience'. What kind of 'sentiments' each one acquires is thus very largely " a matter of accident "—the outcome of blind association operating under the influence of gregarious and sympathetic ' instincts ' similar to those Galton had observed among the wild cattle of Damaraland.[1] The detailed differences, he suggests, would make a fruitful topic for future research. The human models each child comes to admire, the stereotyped conceptions he venerates or derides, his ' working religion ' (the word he says, is used " in its larger sense ")—all this could be studied by statistical procedures, and the results would shed a flood of light on the problem of motivation. " Here," he concludes, " the power of Nurture seems very great "; it " sets up a kind of atmosphere ", which " affects large classes of people in very similar ways ", and thus " gives a fallacious sense that these widespread modes of behaviour are natural instincts ".[2]

From Nurture he turns to Nature; and this forms the subject of the rest of the *Inquiries*. After casting about for some practicable means of " distinguishing between the effects of the tendencies that are implanted at birth and those that are imposed by the special circumstances of the individual's after-life ", he finally hit on the happy idea of making a comparative study of the histories and characteristics of twins. This " new method ", he believed, might enable us " to weigh in the scale the effects of Nature and Nurture, and ascertain their respective shares in framing the dispositions and the intellectual abilities of men." He notes the importance of discriminating between different types of twin, and particularly the need to secure comparable data for monovular twins who have been reared apart and binovular twins who have been reared together. His own results, largely anecdotal at this preliminary stage, are reported in some detail. His main conclusion is that " Nature prevails enormously over Nurture when the differences in Nurture do not exceed what is commonly found among persons brought up in the same rank of society."

After this we might expect a full discussion of the inheritance of ' Intellectual Differences '. But the section that bears this heading is tucked away in another

[1] For the ' herd instinct ' see *Inquiries*, pp. 72f. Darwin had made much the same point (cf. *Descent of Man*, I, pp. 156–167).

[2] It was this rough and ready sketch which suggested to McDougall his attempts to study ' The Development of the Sentiments ' (*Introduction to Social Psychology*, chaps. V–IX: his own conclusions were largely based on daily records relating to the development of his own children and their companions). But the whole investigation is well worth carrying out afresh on the lines sketched out by Galton.

portion of the book, and consists merely of a dozen lines referring to his two previous volumes. There are, however, several instructive sections and appendices describing his early attempts to produce standardized tests, such as his calibrated whistle for the upper limit of audible pitch and his geometric series of weights for measuring the delicacy of weight perception. The principles underlying these methods of measurement, he tells us, are quite applicable to other senses and to other faculties. He records the interesting observation that, on an average, acuteness of sense-discrimination is " highest among the intellectually ablest ", e.g. among the Fellows of the Royal Society whom he had tested. It was this and similar findings that led Spearman to put forward his well-known theory that 'general intelligence' and 'general sensory discrimination' are identical and that intelligence itself can best be measured by tests of sensory discrimination.[1]

The closing sections of the *Inquiries*, like those of *Hereditary Genius*, are concerned with tentative reflections on ' the ability of nations ' and ' the influence of man upon race '—themes which Galton was to develop in much fuller detail later on. In these early speculations, as Professor Darlington points out, " Galton foreshadows a genetic interpretation of the history and the structure of society ". He begins by emphasizing " the vast variety of natural faculty in members of the same race "—a variety which most commonly results from the " intermixture of races " and provides the raw material for selective agencies to work upon. The larger and more heterogeneous the nation, the greater will be the range of variation: the greater therefore will be the chances that such a nation —once it has realized the importance of encouraging and educating its ablest members—will become a ' dominant race '.[2]

Human evolution, we are told, has continued throughout the historical period, and is still going on around us. Hardly any spot upon the earth remains tenanted by its original or earliest stock. The races that now inhabit Egypt and Mesopotamia, Italy and Greece, Australia, South Africa and the United States, are different in physique, in colour, and probably (so Galton believes) in mental and temperamental qualities, from those that inhabited them a few centuries ago. In Western Europe the dominant classes of today are descended from families that were quite unknown to history before the industrial revolution. In North America a group of bold and independent whites, who regarded

[1] See for fuller details, *J. Anthrop. Inst.*, XII, 1883, pp. 472f. Galton notes, however, that occupational experience may at times enhance sensitivity. He declares that " as a rule, men have more delicate powers of discrimination than women ", though in a later paper he qualifies this premature generalization, saying that he found that with certain senses—e.g. the sense of touch and discrimination of colour—women are on an average superior. It will be observed that Galton's classification of mental processes was largely borrowed from Bain. Bain held that intellectual processes were based on the apprehension of sensations, or of the revived sensations known as ' images ', and were developed mainly by the processes of association. He held too that " the primary attribute of intelligence is the consciousness of difference, or Discrimination ". It was this contemporary view that both Galton and Spearman supposed that their experiments confirmed.

[2] He suggests, for example, that the Chinese, once they have " overcome certain of their peculiar religious prejudices, might make their industrial and social influence felt in many distant regions ", and perhaps even " become one of the most effective of the colonizing nations ".

themselves as a community of equals no longer handicapped by the mediaeval tradition of feudal rights or aristocratic privileges, have, in the course of two or three hundred years, evolved into a nation with a class structure quite as well marked as that of any European society today. Such changes, he contends, cannot be accounted for solely by environmental conditions or solely by genetic conditions, but only by a continual interaction between the two—an interaction which he conceives as a process of cumulative selection from among the immense variety of individuals constantly provided by genetic differentiation. The process of selection is itself open to intelligent study and to intelligent control; and thus " the power which man possesses of influencing the human stock vests a great responsibility in the hands of each fresh generation ". In short, as Professor Darlington puts it, " the nation which takes most thought about its genetical future is the nation most likely to have a future ".[1]

Galton never tires of reminding us " how new and complex the problem is"; and he insists again and again on the need for scientific research. He ends his book with a practical suggestion as to the ways in which such researches might begin. Two of the most obvious modes of selection arise from variations in health (under which he includes mental defect as well as susceptibility to physical disease) and variations in fertility. He therefore appeals to the " medical profession " to lead the way by exploiting their opportunities for genetical investigations—an appeal which has since been abundantly justified.

Both in the *Inquiries* and in other publications Galton drops frequent hints revealing how keenly he was interested in what is loosely termed the psychology of religion. The first edition of the book included some " Statistical Studies into the Efficacy of Prayer ".[2] Although the objective results were negative, he stoutly defends the subjective value of prayer. " A confident sense of communion with God must necessarily strengthen the heart "; but even agnostics may rejoice in the knowledge that they " have a brotherhood with all that is ".

In the early seventies—ten years before the foundation of the Society for Psychical Research—he became interested in spiritualism, and witnessed several demonstrations given by Dunglas Home (the reputed original of ' Mr. Sludge the Medium ' in Browning's poem) and by other spiritualists. Home's séances were attended by many eminent people of the day—A. R. Wallace and Sir William Barrett (who were convinced), Darwin and Huxley (who considered Home a fraud), George Eliot, Mrs. Browning (who was completely swept away),

[1] ' The Control of Evolution in Man ', *Proc. Roy. Inst.*, XXXVII, 1958, no. 165.

[2] E.g., calculations show that " members of the Royal Houses, whose longevity is most widely prayed for, have, of all groups, the least average length of life ". As may easily be imagined, all this gave a good deal of pain to his Anglican friends: for (to quote his own quotation from *Hudibras*)

As 'twas said, he scarce received
For gospel what the Church believed.

Accordingly he omitted the whole discussion from the second edition. His own belief appears to have been that " our personalities may be transient but essential elements of an immortal and cosmic mind " (*Inquiries*, p. 196). But he was reluctant to commit himself to any view that had not been empirically tested. As the years went on he endeavoured to make his own eugenic creed—" working for the good of the race "—the basis for a kind of religion.

and Browning himself (who was infuriated). In an early letter to Darwin, Galton writes that he has on more than one occasion attended sittings at (Sir William) Crookes' house, and feels " very disinclined to discredit them: . . . I really believe what they allege—that the people who come as men of science are so opinionated and obstructive that the séances rarely succeed with them ". Many of the details reported by Galton (e.g., the alleged communications from Benjamin Franklin) tally closely with the description given in Browning's poem. Later he appears to have become disgusted with the frequent mixture of fraud and evasion and the " nonsensical twaddle contained in most of the so-called messages ".

This, however, was but one of his many minor interests. The establishment of what he called an ' Anthropometric Laboratory '[1] was something far more momentous. It furnished the starting-point, and to a large extent the model, for the many ' psychological clinics ' or ' child guidance centres ' subsequently set up in Britain, America, and elsewhere; it formed the birthplace of the whole ' mental testing ' movement; and it symbolized the beginning of experimental psychology in this country. The laboratory was opened during the International Health Exhibition in London in 1884. When the Exhibition closed, it was moved first to the Science Museum in South Kensington, and then to University College. The College still preserves a few of the large orange posters which announced that an " Anthropometric Laboratory for the Measurement of Human Form and Faculty has been instituted, partly for anthropometric experiment and research, partly to familiarize the public with the methods and uses of human measurement, and partly for those who desire to learn what are their bodily and mental powers or those of their children, or to obtain timely warning of remediable faults in development. Charge, threepence each to those who are already on the register, fourpence to those who are not ".

" The leading idea ", so Galton explained later on in his *Memories* (p. 267), " was that the measurements should ' sample ' a man with reasonable completeness: they should measure *absolutely* wherever possible, otherwise *relatively* among his class fellows ", i.e. by 'ranks' or 'percentile grades'.[2] Many of the routine measurements were purely physical—tests of bodily strength, measurements of the body and its parts (including the head), observations on hair colour, eye colour, handedness, and the like, and a general note of the examinee's health.

[1] It will be noted that throughout his published writings Galton deliberately avoids such terms as ' psychological laboratory ' or ' psychological research '. This was partly because in those days the words would have suggested to the general public that the laboratory was intended for ' psychical research ', or, as we should say today, for ' parapsychology ', but chiefly because he disliked the idea of human personality being split into two distinct halves—a mind that is studied by the philosopher or psychologist and a body that is studied by the physiologist or doctor—a ghost loosely coupled with a corpse. ' Bodily ' and ' mental ' were for him two complementary aspects of one individual man; and their investigation formed merely two special departments of a single branch of science, which he preferred to name ' anthropology ', that is the ' study of man ' in the broadest sense of the phrase.

[2] This device was first suggested in *Nature* (1874) and described more fully in *Phil. Mag.*, XLIX, 1875, pp. 33–46.

The rest of the examination was essentially psychological. This was designed to cover three main levels: first, the simple sensory and motor capacities, secondly, associative processes—memory, habit formation, imagery, reaction time, and the like, and finally, what were designated ' higher mental processes '.[1]

For much of his work he had the help of a young American psychologist, J. M. Cattell, who had been studying with Wundt at Leipzig, and acted for a time as Galton's assistant in London. However, in 1888 Cattell was recalled to occupy the first chair of psychology established in the States; and it was principally owing to his introduction of Galton's ideas that mental testing became so popular in that country.[2]

Data collected in this way formed the basis of Galton's next most important work—*Natural Inheritance*, published in 1889. As the title implies, its purpose was to discuss the need for studying the basic principles of biological transmission by scientific methods, and to indicate how this might be done. In many ways his theory of inheritance resembles that put forward by Mendel. In an introductory section he observes that " all living things are in one aspect individual and composite in another. We seem to inherit bit by bit. Inheritance may therefore be described as largely, if not wholly, 'particulate'; and as such it will be treated in these pages." No doubt many human characteristics—height and weight, for instance—exhibit a graded distribution; but each of these, Galton argues, can be regarded as " a fine mosaic with elements too minute to be distinguished ". Here we have a clear anticipation of the principles of multifactorial inheritance, where in Galton's phrase " the multiplicity of quasi-independent elements " combine their effects, and so produce the normal frequency distribution and the varying degrees of family resemblance that we measure by our correlations.

[1] The scheme and the phrase ' higher mental processes ' were, I believe, due largely to suggestions from Professor Croom Robertson, Sully's predecessor at University College, founder and editor of *Mind* (1876), and a close friend of Galton: (see *Memories*, p. 267, and J. Sully, ' Reminiscences of Professors ', *Univ. Coll. Gazette*, III, 1901, p. 250f.).

Galton displayed his usual mechanical ingenuity in designing suitable instruments and other materials. The ' whistles for determining the upper limit of audible sound ' (referred to above), were invented as early as 1866; ' apparatus for testing the delicacy of muscular and other senses ' in 1883; methods for the ' measurement of character ' were described in the *Fortnightly Review*, 1884; other devices are described in *Human Faculty*. Little progress was made in tests for ' higher mental processes ' until the beginning of the present century.

Within the first two or three years over 9,000 persons were measured at the laboratory, ranging in age from under 8 to over 80. One of the earliest examinees was William Gladstone, the Liberal Prime Minister. Gladstone was very proud of the fact that he took an outsize in hats; and, when the measurements were completed, could not resist saying: " I imagine, Mr. Galton, that is the largest headsize that your laboratory has hitherto encountered ". Galton, we are told, replied: " I fear, Mr. Prime Minister, that you must be rather unobservant ". (Galton himself owned a still larger head.) " And in any case, he added, " I have come to the conclusion that to *assess* ability you must *measure* ability, and not merely measure skulls ".

[2] See J. M. Cattell, ' Mental Tests and Measurements ' (with an Appendix by Galton), *Mind*, XV, 1890, pp. 373–380.

V. Statistical Techniques

Regression. Among statistical psychologists and indeed among statisticians generally Galton's name and reputation are commonly linked with the concept of correlation. This does him less than justice. But let us take this particular technique as a starting point and see how the concept arose.

Mendel, it may be remembered, was interested chiefly in discontinuous characteristics, such as flower colour. Galton, on the other hand, devoted his attention mainly to graded characteristics, no doubt because almost all the measurable characteristics of human beings are of that type: discontinuous characteristics (like eye-colour) which are subject to what he called ' alternative heritage ' he examined more briefly. The clue to inheritance was to be found, so he believed, in the different amounts of family resemblance exhibited by persons having various degrees of kinship; and accordingly he cast about for some method of measuring the degree of resemblance. By a curious coincidence his earliest investigations, like those of Mendel, were concerned with inheritance in peas: in Mendel's experiments they were edible peas; in Galton's they were sweet peas.

On measuring the size of seeds for both mother and daughter plants, he discovered that, when the mother plants had produced large seeds, the daughter plants also produced large seeds, but the " amount of the increase over the average " proved to be much smaller. In general, so it appeared, " for every increase of one unit on the part of the parent seed there is a mean increase of only one-third of a unit in the filial seed ". The daughter plants in fact tended to revert to the general mean.[1] He reached much the same result when, a few years later, he compared the heights of parents with their adult offspring. On taking a batch of tall fathers—e.g., those whose heights was three inches above that of the average adult—and then measuring the height of their adult sons, he found that the mean height of the latter was only one inch above the general average. He termed this reduction in the mean height of the second group its ' regression ', and the ratio of the two deviations—in this case 1/3—the ' regression coefficient '.

Galton was fully aware that this mode of arguing involved certain assumptions which required empirical confirmation, namely, that the fraction remains constant for all the groups (i.e., that the ' regression ' is ' linear ', as we should now say), and that the ' dispersion ' of the various sub-groups about their respective means is the same (i.e. in Pearson's terminology, that the 'arrays' are ' homoscedastic '). But he regards his earlier data and figures as offering illustrations rather than proofs. His theoretical demonstration proceeded not by considering resemblances or by calculating correlations, but reasoning along the lines of what Fisher has taught us to call an ' analysis of variance '. As his novel

[1] The experiments were described in a lecture delivered at the Royal Institution in 1877: the diagram in his notes illustrating the results obtained must contain the first regression line ever drawn. The peas were measured by arranging 100 in a row, and then measuring the length of the row in inches. Similar results were also observed for the weights of the seeds.

ideas were continually evolving throughout these earlier researches, it is not surprising if his nomenclature and symbols change from time to time in a somewhat confusing way and there are occasional slips in his formulae. The consequence is that the modern student too often gives up the attempt to follow his rather groping arguments. I shall therefore summarize the gist of his demonstrations first of all in terms of symbols that are a little more familiar.

The problem in his first paper is essentially the problem of prediction: given, for example, the height $(m \pm x_i)$ of a particular individual, i (where m denotes the general mean), what will be the most probable height $(m \pm y_i)$ of his brother? Galton assumes that this can be found from the equation

$$y_i = w_{yx} x_i, \tag{1}$$

where w, he says, is " what I call the ratio of regression ". Thus $w_{yx} = y_i / x_i$; and, he adds, " I shall presently show that the value of y_i / x_i is constant for all statures in the same degree of kinship."[1]

His basic postulate is that " natural peculiarities are due to two different causes: the one is Family Likeness, the other Individual Variation ". The word ' peculiarity ' is used in a technical sense " to signify the difference between the amount of any faculty (or other characteristic) possessed by a man and the average of that faculty possessed by the population at large," i.e., it signifies an individual 'error' or deviation from the mean (m). " Family likeness," he says, must be " due to a *common cause* "—to a " factor of stability."[2]

Let us therefore write g for the common or general factor, and s_x and s_y for the individual or specific factors, both being uncorrelated with g. Then

$$x = g + s_x \tag{2}$$

$$y = g + s_y. \tag{3}$$

Squaring and taking averages we have (since $\Sigma gs = 0$)

$$\sigma^2{}_x = \sigma^2{}_g + \sigma^2{}_{sx}, \text{ and } \sigma^2{}_y = \sigma^2{}_g + \sigma^2{}_{sy}. \tag{4}$$

Thus, the observed dispersion in either sample is (as Galton puts it) " compounded of two superimposed and independent systems of dispersion ", i.e., in his own symbols, $q^2 = b^2 + c^2$: " in other words, q corresponds to the hypotenuse of a right-angled triangle of which the other two sides are b and c " (the 'law of vector addition', as Maxwell Garnett later termed it).

From the theory of correlation we have

$$r_{xy} = \frac{\Sigma x^2}{\sqrt{(\Sigma x^2 \, \Sigma y^2)}} = \frac{\sigma^2{}_g}{\sqrt{\{(\sigma^2{}_g + \sigma^2{}_{sx})\,(\sigma^2{}_g + \sigma^2{}_{sy})\}}} \tag{5}$$

$$= \frac{\sigma^2{}_g}{\sigma^2{}_g + \sigma^2{}_s} = w_{xy} = w_{yx}, \tag{6}$$

when (as in the case of correlation between brothers) the two variances are equal.

[1] ' Family Likeness in Stature ', *Proc. Roy. Soc.*, XL, 1886, pp. 50f. (section headed ' Regression '). I have substituted y_i / x_i for Galton's x'/x.

[2] *Natural Inheritance*, pp. 9f. and 194f. In this later publication the treatment and the formulae are much the same as in the earlier paper, but the theoretical discussion is fuller and clearer.

If, however, we assume that the *given* measurements contained no specific factor, i.e., that $x_i = g_i$, then we obtain from eqn. (5)

$$r_{xy} = r_{gy} = \sqrt{\left(\frac{\sigma^2_g}{\sigma^2_g + \sigma^2_s}\right)}. \tag{7}$$

Galton seems at times to confuse the two cases.

His other illustrative problem is the prediction of the height of adult sons (y) from that of their midparents (x). In this case therefore we have

$$w_{yx} = r_{xy}(\sigma_y / \sigma_x) = \frac{\sigma^2_g}{\sigma^2_g + \sigma^2_{sx}}. \tag{8}$$

Let us now turn to Galton's own deductions from his first hand observations. Instead of the standard deviations σ_x or σ_y, he takes the ' probable errors ', which he designates p (*Family Likeness*, p. 50). He estimates them by calculating the ' quartile values ' (q). In his main equations, however, he employs p for *both* the variabilities. To avoid the consequent confusion I shall therefore add the suffixes x or y. The data that he uses to illustrate and verify his formulae consist of (1) " heights of brothers more than 24 and less than 60 years of age ": (these he obtains from just under 300 families " containing in the aggregate 783 brothers "); (2) " heights of 205 couples of parents, with 930 children of both sexes ": here he first "transmutes the female measurements to their adult equivalents" (by multiplying the former by 1·08), and then takes for the measurement of the mid-parent " the imaginary mean of the father and mother " (*loc. cit.*, p. 53). His measurements for adult males range from 61 in. to 75 in. with a mean at 68 in. (or a fraction over). In tabulating the frequencies he subdivides this total range into 15 sections of one inch each, with deviations of -7, -6, . . . , -1, 0, $+1$, . . . $+6$, $+7$ in. above or below the general mean.

Consider first of all just one individual. John Brown, say, whose height is 71 in. ($x_i = +3$ units): what will be the most probable height of one of his brothers? To determine this we should calculate the average of all the brothers in the Brown family: the heights of the individual brothers will of course differ somewhat from each other; but the variation will be decidedly less than the variation in the whole population. " The science of heredity," however, " is concerned with groups rather than with individuals." Let us therefore consider the brothers, not of a single individual, John, in a single family, the Browns, but the larger group formed by the brothers of *every* individual whose height is the same to the nearest inch, viz., $+x_i$ units. Such a ' composite family ' Galton calls a ' co-fraternity '. He now considers measures for three types of variation: (i) the variation of all adult *individuals* about the mean of the *general* population to which they belong: he calls this p; (ii) the variation of the *means* of the several co-fraternities about the mean of the general population: he calls this d; and (iii) the variation of the *individuals* in a given co-fraternity *about the mean* of that co-fraternity: this he calls f. Clearly, expressed in current terminology, what he is really doing is analysing (i) the variance of the total population into (ii) the variance *between* co-fraternities, and (iii) the variance *within* co-fraternities.

All the individual deviations may, he says, be regarded as 'errors' obeying the exponential or 'normal law of error'; and "from a well-known property of the law of error we obtain an equation which assumes the form

$$p^2 = d^2 + f^2 ;\text{"} \tag{9}$$

in other words, he treats the variances as additive. But, he continues, $w_{yx} = y_i/x_i$ (eqn. 1): i.e. the regression coefficient is by definition the ratio of the expected deviation of a brother of John to the actual deviation of John himself, or rather the average of all such ratios. Therefore $w^2{}_{yx} = d^2/p^2{}_x$, i.e., $d^2 = w^2{}_{yx}p^2{}_x$; or dropping subscripts because $p^2{}_x = p^2{}_y$, $d^2 = w^2p^2$. This gives us a theoretical equation which we ought to be able to verify from our empirical data, viz.,

$$p^2 = w^2p^2 + f^2, \tag{10}$$

that is,

$$w^2 = \frac{p^2 - f^2}{p^2} = \frac{c^2}{c^2 + b^2}, \tag{11}$$

where c^2 may be regarded as representing the variance of the common factor, and b^2 that of the specific factor.[1] Thus, as Galton says, $c^2/(c^2 + b^2)$ "is the value of the Fraternal Regression"[2]. His equation 11 is our equation 8.

Galton now proceeds to check this result from his own data. (i) From the measurements for brothers we have $p = 1{\cdot}71$, $f = 1{\cdot}27$, and $w = 2/3$ (determined by averaging the regressional ratios for the different co-fraternities). Substituting in eqn. (10) we obtain

$$(2/3 \times 1{\cdot}71)^2 + 1{\cdot}27^2 = 2{\cdot}929 = 1{\cdot}71^2 \text{ (approx.)}.$$

(ii) From the measurements for mid-parents and their offspring we have for the variability of the former (assuming, as Galton does, that mating is random) $p^2{}_x = 1/2 \times p^2{}_y = 1{\cdot}46$ or $1{\cdot}21^2$, $f^2 = 1{\cdot}50^2$, and $w_{yx} = 2/3$ as before. Equation (10) should now be written

$$w_{yx}{}^2 p_x{}^2 + f^2 = p^2{}_y$$

or $(2/3 \times 1{\cdot}21)^2 + 1{\cdot}50^2 = 2{\cdot}911$, which again is approximately correct. To determine the converse regression, w_{xy}, Galton gives the equation[3]

$$p^2{}_x w_{yx} = p^2{}_y w_{xy}, \tag{12}$$

from which he obtains $w_{xy} = 1/3$.

[1] *Loc. cit.*, pp. 50, 51; *Natural Inheritance*, p. 114.

[2] *Natural Inheritance*, p. 127. As originally printed the value given for the Fraternal Regression is $\sqrt{\{c^2/(c^2+b^2)\}}$ both here and on p. 70. But in Galton's own copy the radical has been scratched out, and the equation on p. 70 altered, in Galton's own handwriting, to $c^2/(c^2+b^2)\ x$. The correct value appears in Appendix C, p. 224.

[3] I have substituted my own notation; Galton here (*loc. cit.*, p. 57) writes c^2 for $p^2{}_x$, which is doubly confusing, since c has already been used with another meaning. It should be added that the values obtained for the regressions differ somewhat from those more recently obtained from larger and more carefully chosen samples of the total population. Galton is aware that b^2 cannot be identified with f^2, as eqn. (11) might at first sight suggest. For brothers he estimates b as about $1{\cdot}06$ ('Family Likeness', p. 59). On this basis we should have $w = 1{\cdot}80/(1{\cdot}80 + 1{\cdot}12) = 0{\cdot}62$.

The student will find it highly instructive to compare Galton's treatment of the analysis of variance with that adopted in more modern textbooks (c.f. for a general statement of the problem at its simplest, Tippett, *Methods of Statistics*, Tables XXIV and XXXVIII (pp. 94 and 122), and for the correlation between brothers, Fisher, *Statistical Methods for Research Workers*, Table 39, p. 213. We may note that Fisher's formula for the correlation $\rho = A/(A+B)$ is virtually the same as Galton's (eqns. (6) and (11) above).

Galton then turns to consider the bivariate distribution. In his *Memories* (p. 302) he relates how, while waiting on the platform for a train, he started poring over the tabular diagram for the heights of parents and their children. It then struck him that the contours joining points of equal frequency " ran in concentric ellipses ". He started brushing up his knowledge of conic sections; but in the end he submitted his problem to Hamilton Dickson, a Tutor in Mathematics at Cambridge. Dickson at once sent him the formal solution,[1] adding that most of his mathematical class were able to solve it. Galton tells us that he " never felt such a glow of respect towards the wide sway of mathematics as when (Dickson's) answer arrived confirming my laborious statistical conclusions with far more minuteness than I had dared to hope ". This perhaps is scarcely the feeling the modern student experiences when he tries to follow Dickson's somewhat tortuous exposition.[2]

Galton has found that the offspring of parents (or midparents) whose deviation is x will vary about a mean of $y = w_{yx}x = (r\sigma_y/\sigma_x)x$ with a variance of $\sigma^2{}_y\ (1-r^2)$, and that their frequency distribution will obey the ordinary normal law, i.e. (in the ordinary notation) that, if there are m offspring of the n parents having a deviation of x, the number of offspring having a deviation of y will be

$$z = \frac{mn}{\sigma_y \sqrt{(2\pi)} \sqrt{(1-r^2)}} \exp - \frac{1}{2\sigma_y{}^2(1-r^2)} \left(y - \frac{r\sigma_y}{\sigma_x} x\right)^2. \tag{13}$$

But

$$n = \frac{N}{\sigma_x \sqrt{(2\pi)}} \exp - \tfrac{1}{2} \frac{x^2}{\sigma_x{}^2}, \tag{14}$$

where N is the number in the total population. On substituting for n in the preceding equation, we then have for the exponent (omitting the factor $-\frac{1}{2}$)

$$\frac{x^2}{\sigma_x{}^2} + \frac{1}{\sigma_y{}^2(1-r^2)} \left(y - r\frac{\sigma_y}{\sigma_x} x\right)^2. \tag{15}$$

This, in modern notation, is what Dickson calls " the exponential of the exponent which appears in the value of z in the equation of the surface of frequency " as formulated by him (without explanation) at the outset of his proof.

[1] It is printed as an appendix to ' Family Likeness' (*Proc. Roy. Soc.*, XL, pp. 63–66) and to *Natural Inheritance* (pp. 221–224). The value evidently assumed for r^2 (which does not appear explicitly in Dickson's paper) is $w_{yx} \times w_{xy} = 2/3 \times 1/3 = 2/9$, i.e. $r = 0{\cdot}471$.

[2] Galton's problem, as treated in this appendix (but with his theoretical values substituted for the observed and eqns. (11) and (17) for Dickson's equations), forms an excellent way of introducing the elementary student to the whole subject of correlation and factor analysis.

In his initial equation (1), however, he substitutes Galton's numerical values for the various constants; his later eqn. (7) gives the formula in general terms, putting tan θ for the regression coefficient $r\sigma_y/\sigma_x$ in eqn. 15 above. On simplifying equation 15 and changing to the relative frequency (or probability) we obtain

$$z = \frac{1}{2\pi\sigma_x\sigma_y\sqrt{(1-r^2)}} \exp -\frac{1}{2(1-r^2)}\left(\frac{x^2}{\sigma_x^2} - \frac{2rxy}{\sigma_x\sigma_y} + \frac{y^2}{\sigma_y^2}\right). \qquad (16)$$

which is the familiar equation for the normal correlation surface and was not in fact explicitly given by Hamilton Dickson.

Dickson also calculates the equation to the ellipses " when referred to their principal axes ". This involves rotating the axes of the coordinates so that the coefficient of the product term xy is zero, i.e. so that

$$\frac{X^2}{c^2} + \frac{Y^2}{b^2} = \text{constant}. \qquad (17)$$

He obtains as approximate values $c^2 = 7$ and $b^2 2$. Once again the essential equations are not stated, namely, in modern notation, $\sigma_X{}^2 + \sigma_Y{}^2 = \sigma_x{}^2 + \sigma_y{}^2 = 1 + 1/2$; $\sigma_X{}^2\sigma_Y{}^2 = \sigma_x{}^2\sigma_y{}^2(1-r^2) = 1/2 \times (1-2/9)$. From these we obtain

$$\sigma_X{}^2 = 7/6 \text{ and } \sigma_Y{}^2 = 2/6. \qquad (18)$$

Correlation. Meanwhile Galton had encountered what seemed at first sight a very different problem. If you want to produce an adequate specificaton of any particular individual with scientific accuracy the ideal procedure would be, not to pick out his most salient peculiarities after the fashion of the literary biographer, but to measure all his distinctively human characteristics. But that is clearly impracticable. How then are the most essential to be selected? In France in order to describe, classify, and identify criminals by their physical characteristics, Alphonse Bertillon[1] had recently put forward a scheme based on twelve body measurements—height, length and breadth of head, length of forearm and of middle finger, and the like, all supplemented by a *portrait parlé*, with photographs and a list of distinguishing marks such as scars and moles. Galton, however, believed that several of Bertillon's measurements would vary so closely with each other that only a few would be really informative. Obviously, if you have measured Arsène Lupin's left leg, you don't need to measure his right

[1] Bertillon (b. 1853), originally a teacher of French in Britain, subsequently obtained a post as filing clerk at the Préfecture in Paris. Ethnologists had already made free use of anthropometric measurements; and, after the Franco-Prussian war, both Prussian and French armies became interested in their application. Bertillon, like Galton, was convinced that such methods had both scientific and practical possibilities. His scheme was tentatively adopted by the Préfecture in 1882; and in 1888 he was appointed Chief of the Service of Judicial Identity. (See A. Bertillon, *Signaletic Instructions, including the Theory and Practice of Anthropometrical Identification*, Engl. trans., 1896.) Meanwhile, a simplified version of his ' metric system of identification ' was introduced at Scotland Yard; the British procedure is described by Dr. Garson (who was in charge of it) in *J. Anthrop. Inst.*, XXX, 1900. It should be noted that, in opposition to Galton, Bertillon and Garson were agreed that " the measurements for the different characters would be independent ".

leg; and if you measure his height, is it necessary to measure his legs or his arms at all? The question could readily be answered, so Galton argued, if we could only devise some means of assessing the degree of concomitant variation—or, as he termed it, the ' co-relation '—between height, arm-length, head-length, and so on.

However, the problem is of much wider importance than this. As Galton points out, both the term and the concept are of frequent occurrence in biology.[1] Yet " no previous attempt had been made to define it clearly or to measure its degree ".[2] The fact that, in Darwinian phrase, many ' variations ' were closely ' correlated ' was evident from a study of the data he had already collected in his anthropometric laboratory at South Kensington. Thus, if a man's height is 1 inch over the average, his forearm will be about ¼ inch longer than the average : if his forearm is 1 inch over the average, then he will be taller than the average, not by 4 inches, but by 2½ inches. As expressed by these two values, however, the relations " are not numerically reciprocal "; and the regression coefficient no longer serves. What is needed is a single index-figure, varying between zero and unity.

The solution, he suggests, is to " transmute " the raw measurements of stature, forearm, weight, and so forth (which will be in inches, pounds, or the like) " into units determined by their respective scales of variability . . . namely, the probable error ". When this is done " the direct ratio and the converse are identical, viz., for height and forearm 0·8 to 1·0 ". This therefore is the device he proposed to adopt as a measure of the co-relation. In his autobiography he relates how vividly he recalls the circumstance in which he first grasped this important generalization. " It was in the grounds of Naworth Castle " (the baronial residence of the Howards, the famous Earls of Carlisle, who were remotely related to him.)[3] There " an invitation had been given to ramble freely. A temporary shower drove me to seek refuge in a reddish recess in the rock by the side of the pathway. Here the idea flashed across me, and I forgot everything else for a moment in my great delight ". As Pearson remarks, " that ' recess ' deserves a commemorative tablet ".

He found that for nearly all the body measurements advocated by Bertillon the correlations were surprisingly high—ranging from 0·70 (for height and middle finger) to 0·90 (for height and length of lower leg). The correlations furnished by the head measurements, however, both with each other and with the remaining characteristics, proved to be comparatively low (0·35 to 0·45). His statistics thus fully confirmed the ancient maxim, *ex pede Herculem*—if you can measure

[1] See C. Darwin, *Descent of Man*, 1871, I, pp. 64f., section on ' Correlated Variation ', and the glossary and index to his *Origin of Species*. The term was originally introduced by Cuvier.

[2] F. Galton, ' Co-relations and their Measurement, chiefly from Anthropometric Data ', *Proc. Roy. Soc.*, XLV, 1888–9, pp. 135–145, opening sentence.

[3] The history of the castle, twelve miles north-east of Carlisle, is most closely associated with " belted Will Howard ", who figures in Scott's *Lay of the Last Minstrel*.

just one part of a body or a corpse, then you can reconstruct fairly accurately the measurements for the rest—except, significantly enough, for the skull. From the foot alone you can tell whether your man is a giant like Hercules, or a dwarf like Tom Thumb, or what his approximate measurements must be if he is intermediate between the two. In short, underlying all the various measurements of the body lies a " common cause ", or, as we now should say, a " general factor ", more or less modified by the effects of certain more or less " specific factors ".

He goes on to indicate the obvious merits of the correlation coefficient for investigations into heredity. Here again, as in studying the resemblance between adult brothers, the variabilities will ordinarily be the same for both correlated groups. In such cases the two regressions will be identical; and, as indeed he had stated in *Natural Inheritance* (p. 132), " the regression then provides a convenient and correct measure of family likeness ". But, when comparing the stature of adult children with that of their ' midparent ', he had already encountered an instance in which the variabilities differed; and of course the same situation arises when we wish to compare measurements of parents with those of children who are not yet fully grown. Evidently, therefore, the new coefficient, which in point of fact is the geometric mean of the two regressions, is the most general form of index-figure; and it is available for all conceivable cases.

This short but epoch-making paper is concerned merely with the theory of the subject. He notes that the detailed results incidentally obtained " are of interest especially in connexion with M. Bertillon's system "; but with this and other practical applications he proposes to deal elsewhere.[1] The most succinct statement of the obvious corollary is contained in his *Memories* (p. 251). " The incorrectness [of the Bertillon system]," he says, " lay in treating the measures of different dimensions of the same person as if they were *independent* variables, which they are not; thus the chances against a mistake in identification have been enormously overrated." Bertillon, in filing his records, sorted each criminal into three broad classes for each measurement—below average, medium, and above average; he then assumed that with n measurements this would yield 3^n different pigeon-holes or compartments. But this is a manifest fallacy. Almost all the persons of medium height will have arms and legs of medium length; similarly for those whose height is above or below average. Thus in respect of many of his compartments the anthropometer will find himself in the position of Old Mother Hubbard. Consequently, what is really needed is a method of classification based on a set of *uncorrelated* measurements.[2]

Factor Analysis. In the books and papers I have cited the reader continually comes across pregnant hints of highly original notions and techniques, many of which were taken up and developed by statisticians and statistical psychologists

[1] Cf. *J. Anthrop. Inst.*, XVII, pp. 346f, and XX, pp. 198f.

[2] The argument is perhaps most clearly stated by Edgeworth in his criticism of Bertillonage (see this *Journal*, II, p. 102 and refs.).

during the next few decades.[1] In *Natural Inheritance*, for instance, Galton suggests *combining* measurements for the same characteristic from several relatives, duly weighted, to secure a better prediction of the corresponding measurement for the particular individual in question—the problem of multiple correlation. And his later paper on 'Co-relation' concludes with a brief reference to the possibility of combining measurements for different characteristics obtained for the same individual with a view to securing a more accurate estimate of the degree to which one particular variable is correlated with the joint effect of *n* other variables. He envisages two cases: first, that in which the initial measurements are correlated, and secondly that in which they vary independently. Indeed, as Pearson observes " by 1889 Galton had completed his theory of normal bivariate classification; . . . the next stage was the development of multivariate classification . . . This he endeavoured to reach by a short cut", but here he was severely handicapped, because " for him the geometry of *n* dimensions remained a closed book " (*op. cit. sup.*, II, pp. 380f.).

One major problem was continually at the back of his mind—how to determine the underlying common factors. In the paper just cited he argues that correlation is itself " the consequence of the variations in the two organs being due partly to a *common cause* ". Could a method be found for establishing such causes objectively, then, he believed, we should be able to reach a sound scientific procedure for classifying both the persons and their characteristics. As we have seen, like so many of his relatives, Galton was an ardent believer in classification. But to be genuinely scientific a classification, he considered, should not be just a neat, plausible, quasi-scholastic scheme, excogitated by armchair reflection: it should be empirical, causal, and quantitative. The principles on which such classifications were to be based—the *fundamenta divisionis*, as the logicians would say—should be independent of each other, and, wherever possible, identifiable with the main contributory or ' partial ' causes, i.e., with what would today be termed the ' orthogonal components ' or ' factors ' that contribute most to the variance. In general he recognized three kinds of classificatory principles—generic, specific and individual. Thus, as he puts it, " Personal Forms may be divided into Types, Subtypes, and Deviations."[2]

[1] He was always shy of committing himself to explicit accounts in print until his ideas had been objectively tested, but ready to expatiate on them in conversation: hence many of the far reaching hints buried in his various publications have been overlooked or misinterpreted by those who did not enjoy a more direct access to the highly ingenious ideas with which his fertile mind was always filled. For an illuminating discussion of these and other implications of Galton's correlational techniques see E. A. Peel, *Brit. J. educ. Psychol.*, XXIV, 1954, pp. 9–16.

[2] *Natural Inheritance*, pp. 25f. This threefold division re-emerges under various names again and again. It was evidently suggested by the Linnaean (or rather Aristotelian) scheme of genera, species, and individuals—terms which Galton himself uses in working out his classification of finger prints (cf. ' Patterns in Thumb and Finger Marks; Their Arrangement into Naturally Distinct Classes, and the Resemblance of their Classes to Ordinary Genera ', *Phil. Trans.*, CLXXXII B, 1891, pp. 1–23). Similarly, as we have seen, in discussing the inheritance of mental traits, he distinguished ' general abilities ', ' special aptitudes ', and ' individual peculiarities '.

The key to the mathematical solution of the problem was really contained in Hamilton Dickson's discussion of Galton's contour ellipses. It consisted in " referring the ellipses to their principal axes ", since the principal axes are necessarily orthogonal. The very shape of the ellipses obtained by plotting the data for body measurements—their conspicuous length and their constricted breadth—were in Galton's view clear evidence of the overriding importance of the factor common to both the correlated groups, namely, the hereditary tendency shared by parents and children in one instance and by the pairs of brothers in the other.[1] He went on to show how this common causal factor appeared and re-appeared, though in a progressively attenuated degree, in later generations and in remoter relatives. " The process throughout," he says, " is one of proportionate dilutions ": even the nearest relatives are " not entirely of the same blood ", but " the blood is, as it were, highly ' saturated ' with the inheritable ingredient; as the kinship becomes more and more remote, so the saturation diminishes." He suggested a rule for predicting its probable or average amount. The parent-and-child regression was 1/3; the brother-to-brother regression was 2/3. Hence, he argued, since a nephew is the son of a parent's brother, the uncle-to-nephew regression would be $1/3 \times 2/3 = 2/9$; similarly the grandparent-to-grandchildren regression would be 1/9, and the cousin-to-cousin only 2/27. In this way it became possible to construct a theoretical set of regression coefficients to represent what he called ' the hierarchy of kinship '—a ' matrix ' (as we should now say) of ' rank one '. His vivid metaphors seemed at the time to supply a convenient terminology for expressing the new ideas. Younger readers, unfamiliar with this early history, have frequently been puzzled by the rather odd and out-of-the-way terms—' saturations ', ' hierarchies ', and so forth—which no longer seem self-explanatory.

Galton attempted to generalize his chief results in the form of a ' law of ancestral inheritance '. At its simplest it states that correlation between a given individual and a relative at the nth remove is r^n. If, as he at one time suggested, we take $r = \frac{1}{2}$, then the correlation between a parent and his child will be $\frac{1}{2}$; between the same person and his grandchild $\frac{1}{4}$; and so on. A similar rule can be deduced from the Mendelian theory of multifactorial inheritance: if for simplicity we ignore the possible effects of dominance, assortative mating, and various other minor complications, we may say that a parent passes on to a child half his or her genes: as a result parent and child (and also two sibs) have half their genes in common. Similarly grandparent and grandchild (or uncle and nephew)

[1] In both his anthropometric and his psychological studies Galton was always more interested in ' general factors ' than in the more specific. At that date indeed, so far as psychology was concerned, it would have been unnecessary to adduce arguments in support of innate ' *special* abilities ' : they were already fully recognized by current faculty theory. On the other hand, the notion of an innate ' general ability ' was a novelty. Spearman, one of his early followers, even went so far as to deny the existence of ' special abilities ' altogether, and was content with the two types of factor revealed in this early analysis.

have a quarter of their genes in common; and generally at each remove the number of genes in common is halved.[1]

The other problem which Galton brought to the fore was, as we have seen, the analysis not of single correlations for a single trait, but of a whole table of correlations, for a series of traits. This clearly entails extending Dickson's notion of using principal axes from two dimensions to three or more. Such an extension would seem fairly obvious to an elementary student of mathematics, once the problem had been put to him. Edgeworth did in fact extend the method to three dimensions, and worked out the results for three physical traits, taking Galton's correlations as his starting-point and applying the "well-known rules for transformation to principal axes," as given in every school textbook on solid geometry. Being strictly " independent " (i.e. uncorrelated) these " hypothetical characteristics ", he argued, would supply a far better basis for classification than Bertillon's method of taking the observed measurements just as they stand. We should then begin by classifying each individual according to ' Characteristic No. 1 ', which, as he rightly says, is a ' factor for general body size '; we should next cross-classify them by distinguishing those who are disproportionately long or short in arm or leg. This gives us $3 \times 3 \times 3 = 27$ sub-classes. Pearson made the whole thing completely general by extending the basic idea to the case of *n* intercorrelated variables, and proposed its application to the very extensive set of bodily measurements collected by the Bureau of Identification at Scotland Yard. After this it was a very natural step to apply the same techniques (with suitable modifications) to measurements obtained with mental tests.[2]

By this time, however, Galton himself had become convinced that, for the objective identification of persons, fingerprints would provide a far surer method than body measurements. In a long series of researches, reported in over a dozen memoirs published between 1891 and 1902, he was able to establish three main conclusions. First, " the pattern of a finger-print remains unchanged throughout life". Secondly, they admit of practical classification, or, as he puts it, of being ' lexiconized '. Thirdly, " the variety of pattern is great enough for mistakes to be beyond the bounds of probability". He calculates that with his scheme the number of different patterns will be of the order of 2^{36}—roughly

[1] For a comparison between theory and observational results see Burt and M. Howard, ' The Multifactorial Theory of Inheritance ', this *Journal*, IX, esp. Table IX, p. 117. In developing his general theory Galton was largely influenced by his hypothesis of particulate inheritance. However, quite often in discussing his law he appears to have supposed that different ancestors handed on their traits separately. Pearson, who wholly rejected the notion of particulate inheritance, introduced other erroneous modifications; see his discussion in *The Grammar of Science*, 1900, pp. 475f., and especially the table on p. 495.

[2] I have described in fuller detail the history of the subject (with relevant references) in the paper already cited (this *Journal*, II, pp. 98f.). So far as the study of body-build is concerned, the most comprehensive investigation hitherto carried out is that undertaken for the Royal Air Force in which correlations between measurements for nine physical traits obtained from 2400 entrants were factorized. The results furnished a theoretical basis for what in those days was popularly termed ' somatotyping ': (cf. C. Banks and C. Burt, 'A Factor Analysis of Body Measurements for British Adult Males ', *Ann. Eugen.*, XIII, 1947, pp. 238–256).

68 thousand million; the population of the world he assessed at about 1·7 thousand million. Hence the odds are about 40 to 1 against the pattern found on a particular finger in one person being found again in a second person. He concludes his argument by reminding the reader that in the story of Jezebel it was said that, besides her skull, only " the palms of her hands and the soles of her feet were left, so that no man might say: ' This is Jezebel.' " But, he adds, " these are the very remains by which her corpse might have been most surely identified."[1]

VI. Practical Applications

The later years of Galton's life were devoted more and more to lectures and articles on the practical implications of the views he had thus developed. Since human achievements depend partly on education and partly on hereditary transmission, it is essential, so he maintained, to apply modern scientific techniques to the improvement of both. For this purpose the first step, he held, must be to increase our knowledge of each contributory process by means of scientific research; and the most obvious place for carrying out such investigations is the school. This indeed he had already realized long before he opened his Anthropometric Laboratory.

" As each hospital fulfils two purposes—to relieve the sick and to advance the science of medicine, so," he argued, " the object of the school should be, not only to educate, but also to promote the science of education." The school was itself an anthropometric laboratory, " ready and waiting for anthropological researches to be carried out there . . . If," he says, "a few masters were willing to codify in a scientific manner their large experience of boys, and to assess and compare their intellectual and moral qualities, classify their temperaments, and describe them as a naturalist would describe the fauna of some new land, what excellent psychological work might be accomplished ". In a later paper, addressed to school teachers and school doctors, he put his proposals in a nutshell: " Anthropometry is the art of measuring the physical and mental faculties of a human being. It enables a short-hand description of any individual to be obtained by recording measurements of a sample of his qualities. Properly chosen, these will define his bodily proportions, his health, strength, and energy, his intellectual capacities and moral character, and will substitute concise

[1] *Finger Prints*, 1893 (Macmillan). In 1893 Mr. Asquith, then Secretary of State for Home Affairs, appointed a committee (consisting of Major Griffiths, the Inspector of Prisons, Mr. Macnaghten, the Chief Constable of the Metropolitan Police Force, and other persons) to inquire into the comparative merits of " the anthropometric system of classification and identification in use in France and the suggested system of identification by means of finger marks ". The committee reported that they were " much impressed by the excellence of Mr. Galton's system ", and " think his conclusions may be entirely accepted ". The representatives of the police force were, I suspect, strongly influenced by the fact that a criminal would be very apt to leave his fingerprints on the scene of the crime; he would not leave his body measurements there. The first recorded case in which finger prints were used in actual evidence was the trial of Harry Jackson for burglary, at the Central Criminal Court on September 13, 1902; and in the following year Galton's argument was strikingly confirmed by the curious coincidence that in the United States two " Will West's " were found with the same body measurements, but with very different patterns in their finger prints.

numerical values for verbose and disputable estimates. Anthropometry thus furnishes the readiest method of estimating whether a boy is developing normally or otherwise . . . But no programme for anthropometry in the school can be considered complete unless it also provides for the collection of further data during the pupils' after-lives. We need to know what is its prophetic value. How far can performance in youth foretell success or failure in after life?" Accordingly he suggested that a kind of school record card or personal file should be kept for each child, to be filled up every leap-year on February 29. This would at once assist both educational and vocational guidance. At the same time plans should be laid for supplementing the case-histories begun during childhood by after-histories carried out at regular intervals during adult life.[1]

As a result of the experience gained from the earlier work in schools, Galton, when President of the Anthropological Section of the British Association, was led to propose an anthropometric survey of the British Isles. The first investigations were confined almost entirely to the collection of physical data.[2] However, a quarter of a century later, in 1903, he suggested repeating the survey, and urged that this time it should include mental as well as physical measurements, McDougall was appointed secretary of the Psychological Committee; and for the purpose of the inquiry initiated a series of researches in his laboratory at Oxford. Their chief aim was to develop and standardize tests of general intelligence and other abilities for use in the schools through which the surveys were to be carried out. McDougall's research students—William Brown, J. C. Flugel, H. B. English, and myself—set to work on this project with much encouragement from Galton. Spearman, who had just returned from studying experimental psychology under Wundt, also came to Oxford, and joined in the scheme.

During the next ten years or so the researches thus started were continued in London, Liverpool, and elsewhere. Then, after prolonged appeals by Sully

[1] See 'Proposal for Anthropological Statistics from Schools', *J. Anthrop. Inst.*, III, 1874, pp. 308–311; *Ann. Rep. Brit. Assoc.*, sect. H, 1877; *Nature*, May 6, 1880; 'Anthropometry in Schools', *J. Prev. Med.*, XIV, 1906, pp. 93–108.

One of Galton's intimate friends was F. W. Farrar, classical master at Marlborough College, and later at Harrow: (he was subsequently appointed Dean of Canterbury, and was already celebrated as the " ablest of the many able scholars to be found among Anglican divines " and the author of the still popular *Life of Christ*). Farrar was able to arrange that something like an anthropometric laboratory should be established at Marlborough and then at Harrow; and a number of other schools followed suit.

Towards the end of the century, as Galton's interest veered more and more towards Eugenics, Sully took over the psychological work of the Anthropometric Laboratory at University College; eventually it became part of the Education Department which he established there in close connection with University College School in 1893. In 1900 the work was transferred to Sully's new Psychological Laboratory under McDougall as Director.

[2] See O. J. R. Howarth (Secretary), *The British Association for the Advancement of Science: A Retrospect*, 1922, pp. 200f. As Howarth observes, the final report of this first inquiry (published in 1883) " is of particular note because on its work were based all the more recent standards and estimates, and its results were found to be of particular importance when the country took stock of its manpower during the war of 1914–18 ".

and Galton, the London County Council resolved to appoint a school psychologist of its own. Since the post was partly a research post, we were able to put into execution many of the plans that Galton had long ago proposed. With the help of research students (chiefly teachers) trained in the various University departments, we made regular surveys of typical boroughs; we hunted up identical twins who had been reared apart; we selected large samples of different types of pupil—gifted, backward, dull, defective, and delinquent—with parallel samples of normal children to serve as control groups; and, so far as possible, we made studies of their family histories and followed them up into adult life. Since in those days conditions in rural areas differed widely from those obtaining in towns, similar investigations were started among children at village schools—in Warwickshire, the Cotswolds, the Cheviots, and elsewhere.[1]

For Galton himself, however, the educational implications of his ' psychometric inquiries ' were something of a side-issue. More and more he had come to feel that the most urgent need was to arouse public interest in the other aspect of the human problem—the study of heredity. From 1870 onwards governments of both main parties had started introducing revolutionary changes in education, taxation, the health services, the reduction of poverty and crime, all calculated to effect marked improvements in the living conditions of the existing generation, but with little regard to their possible effects on the generations to come. Together with concurrent changes in industry, transport, and the applications of scientific discoveries, they had already produced marked alterations in class structure, in marriage customs, and in the birth-rate. Long ago, during his African travels and later during his pedigree-studies of genius, Galton (as we have seen) had been greatly impressed by " the frequency with which one race has supplanted others in various geographical areas ", and by the rise and decline not only of families, but of communities and of nations. As an anthropologist he was familiar with the practice of endogamy and exogamy among primitive tribes; he had noted how many of the most successful nations—the Greek, the British, the North American—appeared to have started with a long spell of outbreeding and crossbreeding, and that at a later stage many of the more influential clans, castes, sects, and social classes, had practised systematic inbreeding. Again and again in the past the conscious insistence on restrictive matrimonial customs and the deliberate introduction of restrictive marriage laws had shown that civilized man had already vaguely realized that, by controlling the mating system, he might also control his own evolution. And it was Galton's growing conviction, based on a firm belief in the Darwinian creed, that what hitherto had been done in relative ignorance ought in future to be guided by scientific research and rational planning.

[1] The study of village communities has several special advantages: far more information is obtainable about the home conditions and the family histories of the children tested, and the striking effects of inbreeding, crossbreeding, and migration (particularly the exodus to the towns) can be more readily demonstrated when the investigation is repeated with the second generation.

The concept and the term 'eugenics' was first explicitly introduced and defined in his book on *Human Faculty*. At that date, however, there was so much to be achieved by the more obvious method of environmental improvement that both scientists and social reformers remained unconvinced or even hostile. Today the welfare state—the utopian dream of the nineteenth century philanthropist—is acclaimed as a reality; extremes of poverty and insanitation have been stamped out, and an educational ladder set up, free to all who can climb it. Yet backwardness and mental deficiency, delinquency and crime remain as frequent as before. It is time therefore that we took up once again the thread of Galton's argument where it was broken off, to see whether after all it may not offer a clue to the Daedalian maze.

Galton himself fully realized that the first step should be further research; and to this project, as he neared the end of his days, he generously devoted much of his fortune. Finally, a codicil to his will bequeathed " all the residue of [his] estate to the University of London for the establishment of a Professorship of Eugenics, with a laboratory and library attached thereto ".[1]

As this brief retrospect sufficiently shows, Galton, in the course of his long life, made contributions of outstanding importance to many widely different departments of knowledge—geography, meteorology, anthropology, criminology, medicine, statistics, and genetics: in any one of these fields, his novel ideas would have made the reputation of a first class scientist. He has been hailed as the pioneer of experimental psychology in this country; and he was the father of statistical psychology as we know it today. Nevertheless, it will, I believe, be chiefly for the impetus he gave to the study of individual differences by his ingenious psychological techniques—mental testing, rating scales, standardized questionnaires, coefficients of correlation and regression, and the application of the normal curve—that Galton will be remembered. When he took it up, individual psychology was just a speculative topic for the fancies of the poet, the novelist, the biographer, and the quack and charlatan on the seaside pier. By the time he left it and handed it on to others, it had been transformed into a reputable branch of natural science—perhaps for mankind the most important branch there is.

[1] In 1901 the journal *Biometrika* was founded by Galton, Pearson, and Weldon, largely to publish the work of the biometric laboratory at University College; the Eugenic Record Office in Gower Street was opened in 1904; in 1906 he endowed a Research Fellowship; two years later the Eugenics Society was formed; and in 1911, the year of Galton's death, Karl Pearson was appointed to the Galton professorship. The *Annals of Eugenics* started as a natural extension of *Biometrika*, and from 1934 onwards, with Sir Ronald Fisher (Pearson's successor in the Galton chair) as editor, became the vehicle for many important papers by Fisher and his associates. Under Fisher too a serological unit was established (now transferred to the Lister Institute). Today there are Institutes for Eugenic research, and Eugenics societies or their equivalent, not only in Britain and America, but in at least half-a-dozen European countries. In Britain almost every leading geneticist—William Bateson, Sir Ronald Fisher, Sir Julian Huxley, Professor J. B. S. Haldane, Professor Darlington, Professor Mather, Professor Penrose—has made contributions to the problems of eugenics and of human inheritance. For a further account of the progress of this aspect of Galton's work, see the admirable survey by C. P. Blacker, *Eugenics: Galton and After* (Duckworth, 1952).

APPENDIX

Galton on 'The Natural Ability of Nations'

The interesting comments which Dr. Isaacs has been good enough to send (see this *Journal* p. 76 below) deserve at least a tentative reply. Like several other critics of my conference paper, he regrets that I did not devote more space to Galton as 'the apostle of eugenics'. My excuse is simply the magnitude and the obscurity of the whole subject. To his final question the short answer is that most present-day geneticists would probably endorse what is vital in Galton's views while modifying much of the detail, whereas most present-day psychologists appear to reject or ignore them almost entirely.

As I have indicated above (p. 40), the basis of Galton's eugenic theories was his firm belief that the rise and decline, not only of families, but also of social classes and nations, cannot possibly be explained solely in terms of environmental conditions—i.e. by the political, technological, economic, and cultural conditions of the time or place; they are largely, if not mainly, the effect of the two universal factors in all evolution—variation and selection. The changes themselves, however, have been spasmodic rather than progressive—a kind of 'evolutionary snakes and ladders' (if I may borrow Mr. Aldous Huxley's phrase). Owing to the constant interaction between environment and heredity, the 'structural forms' (as Galton calls them) both of individuals and of groups tend to get cumulatively modified until they reach a stage of relative stability (cf. *Natural Inheritance*, chap. III); the changes, however, still continue, and sooner or later the state of equilibrium breaks down. Galton cites a number of instances; but he puts them forward, not as furnishing "decisive evidence for demonstrable conclusions", but rather as illustrations of a hypothesis that calls urgently for further research. Nowhere did he attempt to "lay down a blueprint for a future Utopia".

We may at once admit that he was inevitably handicapped by the lack of any precise knowledge about the actual mechanism of genetic transmission. For him 'Nature' is virtually synonymous with heredity in the narrower sense—with individual differences due to differences in *ancestry*. Today we should also recognize the influence of *mutation*—occasional modifications in the genes themselves producing inheritable differences which are usually unfavourable but sometimes beneficial. But there is a third and far more important source of individual differences of which he was wholly unaware—the segregation of genes and their chance *recombination* in sexual reproduction. These last two processes fulfil the function of what Darwin called 'spontaneous variation', with which he coupled the theory of 'blended inheritance'.[1] Subsidiary effects, such as 'dominance' and 'linkage', were of course quite unknown in Galton's day. Galton himself certainly realized that what are actually transmitted must be 'potentialities or tendencies' rather than observable characteristics; but too often he treats the two as identical. Finally, he undoubtedly overestimates the amount of innate difference between one 'race' and another; and indeed his constant use of the term 'race' is somewhat unfortunate.[2] But all this

[1] McDougall adopts both these Darwinian principles quite uncritically together with Buckle's rather naïve conception of the 'race-making period' (e.g., *The Group Mind*, 1920, pp. 208f.). Let me add therefore that I should accept most of Dr. Isaacs' criticisms of 'McDougall's biology'. But the worst defect of his eugenic writings is his wholesale neglect of contemporary developments of the Mendelian theory—already so fully discussed in this connection by Bateson and the Whethams (e.g., *The Family and the Nation*, 1910). In McDougall's case this was the result of Karl Pearson's drastic criticisms of Mendelism as applied to man. Myres, I fancy, often attributes to 'replacement' (e.g., by conquest and extermination) changes in physical characteristics that may more probably be ascribed to Mendelian 'dominance'—a process rightly emphasized by Fleure.

[2] Neither Galton nor McDougall defines the word 'race'. Both accept the late nineteenth century conception which treats human races as fairly clear-cut subspecies; both overlook the fact that almost every 'race' known to history is of very mongrel origin and that differences in language and culture form very poor criteria of race. I shall use the term as a convenient name for what other writers (a little clumsily) have called an 'ethnic group': like such words as 'type', it denotes what is essentially a statistical concept.

makes far less difference to his basic arguments than most critics apparently suppose. And his theory certainly merits a fresh examination, if only because of its relevance to our own situation, now that the ' ice on the rivers of international life ' seems to be breaking up.

The outstanding fact of world history has been the continuous rise of new civilizations and the decay of every civilization previous to our own. The early civilizations of the fertile river valleys—the Nile, the Euphrates, the Indus; the Minoans, the Hittites, the Mitanni; the Persians, the Greeks, the Romans; the empires of the Arabs and the Turks; the ancient cities of Mexico and Peru—all have vanished, some leaving hardly a trace. If pre-communist China seems to provide an exception, it did so largely through a process of protracted stagnation. Five thousand years ago Europe was on the same primitive level as the natives of North America in the 17th century, or the Bushmen whom Galton encountered in the corners of Damaraland, and the tribes of New Guinea at the present day. Why then did the Europeans not remain illiterate Stone Age savages like the Red Indians or the Papuans? A partial answer is that they appropriated the various cultural devices—agriculture, domestication of cattle, metallurgy, writing—from their Asiatic or Egyptian neighbours. Somewhere about the third millennium B.C. " a variety of large-built, large-headed men, of exceptional drive and force of character " (we are told)—the socalled ' prospectors '—led in the first instance by some original genius, who combined the qualities of Noah, Columbus, and the Pirate-King, ventured to cross the seas, searching for, or trading in, copper and tin, and so began importing the Bronze Age civilization of the Nile Delta into Crete—an obvious centre for converging influences and at the same time a convenient bridge; thence they carried it to the Aegean Islands and to Cyprus (the ' copper isle '), and so to the coasts of Hellas and Asia Minor.[1] After that, " all could raise the flowers, for all had got the seed ". Yet this alone can hardly explain how these upstart barbarians manage in the end to outstrip the civilizations of Egypt and Mesopotamia, and, before many centuries were over, vanquish them in their own home lands.

These, in modernized dress, were the kind of problems that Galton sought to answer. His solution was much the same as William James '. " What," says James, " can be the causes that make a community change from generation to generation ? I reply—the accumulated influence of individuals . . . in a word, the presence or the lack of great men."[2]

[1] Cf. J. L. Myres, *Who Were the Greeks?* (1930); Gordon Childe, *The Pre-history of European Society* (1958). The racial affinities of these founders of the ' Early Minoan ' civilization is something of a mystery. A number of archaeologists have held that they were " neither Indo-Europeans nor Semites, but possibly a late Neolithic people related to the Basques "; Sir Arthur Evans identifies them with the Tehenu—refugees driven out from the western Delta, when Narmer (Menes) first united the two Egyptian kingdoms. Quite recently, however, Professor C. H. Gordon claims to have shown that the language of the pre-Hellenic Cretans—the Ετεόκρητοι of Homer—was a variety of North-West Semitic (related to Ugaritic), which in turn suggests that the ' Early Minoans ' were in fact Phoenicians (' dark reds ', as their Greek name implies). Homer, it will be remembered, describes Minos as the son of a princess of Tyre (Europa); and Danaos was a nephew of the King of Phoenicia and son of the King of Egypt. Thus, as so often, legend embodies a fragment of the truth. (I understand that Professor Gordon's studies of the Cretan texts—which are mostly written in the Linear A syllabary, though the latest are in Greek letters—are to be published in the July number of the *Journal of Near Eastern Studies*.)

[2] W. James, ' Great Men and their Environment ', *Atlantic Monthly*, 1880 (reprinted in *Essays in Popular Philosophy*). James, however, in his later footnotes introduces one or two criticisms of Galton's views (for whose " laborious investigations of the heredity of genius ", he tells us, he has " the greatest respect "): they resemble those now raised by Dr. Isaacs, and, like his, seem due to taking emphatic statements out of their context. Galton, he says, argues that " genius, like murder, ' will out ' regardless of opportunity: yet surely many geniuses must have died ' with all their music in them ' ". There must in addition be an environmental need and an environmental selection. The man and the environment are both essential: the crisis must arise to provide the stimulus, and a ' great man ' must be there who can rise to the occasion. " The relation of the environment to the great man is exactly what it is to the ' variation ' in the Darwinian philosophy of evolution: it adopts or rejects admires or condemns, in short—it *selects* him." But all this is precisely Galton's own theory.

Galton believed that he had seen the fundamental causes actually at work, on a small scale but in a typical way, during his travels in South Africa. However, in his later writings he relies chiefly on familiar illustrations drawn from European history. And most historians of the present time (though by no means all) would, I think, agree that he had made out a strong *prima facie* case in his two main instances.

(i) During the century which lasted from about 490 B.C. (battle of Marathon) to 399 B.C. (death of Socrates), Athens, with a population of under 70,000 freeborn males aged 25 or over, produced at least fourteen men of the highest intellectual eminence—a proportion of 1 in 5,000, whereas the average for other nations and Galton's own frequency curve would lead us to expect only 1 in several million.[1] During the 130 years that have elapsed since her liberation from the Turks, with a population ten times that number, she has produced not a single person anywhere near that rank. No doubt in the 5th century B.C. the political and cultural events that occurred in and around Greece just before and during the Periclean age may have acted as precipitating causes. But similar events occurred at other times and in other places without creating anything like this spectacular efflorescence of genius. And both contemporary and later historians have insisted that there must have been something quite exceptional about the character of the people at that time—a " natural disposition which gave them an almost excessive love of freedom, enterprise, and independence ".[2] How exceptional it seemed to others is shown by Xerxes' remark: " If as you say this handful of men are so fond of freedom, then surely they will run away " (*Herodotus*, VII, 104). The conclusion, says Galton, seems inescapable: " by a system of unconscious selection Greece had built up a magnificent breed of human animals—the ablest race of whom history bears a record ".

(ii) To explain the rise of nations has seemed to most writers relatively easy.[3] Galton, like Gibbon musing among the ruins of ancient Rome, found it far harder and far more urgent to account for their decline and fall. Once a civilized society has established and organized itself, how does it ever come to pass that in the course of time it eventually fails in competing for survival with one or other of its less civilized neighbours ?

[1] *Hereditary Genius*, pp. 341f. Galton's list comprises Miltiades, Cimon, Themistocles, Aristides, Pericles, Socrates, Plato, Xenophon, Thucydides, Aeschylus, Sophocles, Euripides, Aristophanes, and Phidias. (He puts the military leaders first because without their courage and brilliant strategy Greece would have undoubtedly succumbed to Persia.) If we go beyond the walls of Athens, we could add other names belonging to the same remarkable ' racial stock '—Zeno, Protagoras, Empedocles, Democritus, Anaxagoras, Hippocrates, etc. In the text I have ventured to make slight emendations in Galton's dates and figures. Galton's own comments on his list dispose of the other criticism made both by James and by Dr. Isaacs. " Mr. Galton," says James, " inclines to think that within any given race an equal number of geniuses of each grade must be born in every equal period of time." But Galton's whole point is that, in cases like the Athens of Pericles and the England of Elizabeth I, the number was *exceptional*; and by the laws of probability exceptional numbers are just what we should from time to time expect. Every whist player knows that, although we consider ourselves lucky when a hand contains more than 2 or 3 trumps, once in about 300 deals we can expect as many as 8 or 9 together. And it is the unusual concourse of geniuses, all born at about the same time, that makes such eras famous in history.

[2] Cf. Herodotus, I, 60 : " The Greek race was of old distinguished from foreign nations as more intelligent and more emancipated; . . . and of all the Greeks the Athenians were counted first in wisdom " (see also id., V, 78 and Thucydides, II, 35–46).

[3] That is the verdict of Dr. Isaacs. " The obvious and familiar reason for the ascendancy of the ancient Greeks," he maintains, " was simply the *migration* of the Greek race into the Greek peninsula at the dawn of their history, and, as a consequence of the migration, *conquest*, followed in the natural course of things by the confident sense of peace and security that a victorious nation always enjoys and the opportunities for cultural development that such a peace always affords." The rejoinder is obvious. To undertake such an enterprise, and to adapt themselves to their new environment, the people concerned must be endowed with certain qualities of physique and character; and they must be inspired by leaders with initiative, courage, and resource. The story of the Israelites, hankering after the fleshpots of Egypt and finding their ark captured by the Philistines, is

The causes he suggests are after all very similar to those put forward by ancient historians themselves: first and foremost, the diminution in the birthrate among the abler and more energetic families and the relative increase in the birthrate among what might

typical of the vicissitudes to which other migrations have so often succumbed. To establish my chief points would require a long digression; but since Dr. Isaacs has challenged me for my facts, I must at least outline the evidence on which I rely.

My main assumption—or rather that of Galton as reinterpreted in terms of Mendelian theory—is that (in accordance with the principle of ' recombination ') increased variability within any given group is nearly always the result of a mixture of breeds. No nation, up to the period with which we are concerned, had sprung from such mingled origins as the people we call the Greeks. The Greek peninsula itself was open to access from the South, East, North, and even the West. But the barriers of mountain and sea (as the Persians found to their cost) made penetration peculiarly difficult.

The foundation of the successive Minoan civilizations was only the prelude. But even at this early date we find Crete and the Aegean islands and shores already occupied, not only by the short long-headed ' Mediterranean ' or ' Brown ' race (coming perhaps from the African plains to the south of the Sea), but also by an assortment of hairy round-heads of the type that had its natural habitat in the continental forests and mountains (and therefore coming presumably from the North or East—most probably from Asia Minor). In 1400 B.C. (i.e. in terms of Egyptian chronology, shortly before the reigns of Ikhnaton and Tutankhamen) the palace régime of Knossos was suddenly and completely destroyed. But during the next two centuries we find frequent mention in Egyptian, Hittite, Jewish, and Greek records, of a fresh set of Aegean assailants—tall and formidable sea-raiders whose name is variously spelt PLST, PLSG, or PLSP (the Pelethi, the giant-like Philistines, the Pelasgians or ' sea-people ', the sons of Pelops). About 1200 B.C. (roughly the time of the Israelite ' Judges ') their concerted attacks were eventually defeated by Rameses III, the last of the great Pharaohs; and many of them were settled on the coastal plains of Palestine to which they gave their name. This is the legendary period of the voyage of the Argonauts, of Paris's abduction of Helen, and the counter-expedition of the Greeks against Troy, and the maritime wanderings of Odysseus. Finally there are further waves of fresh invaders, bearing such names as Akhiyava in Hittite records (Achaian in Greek) and " Javan from the isles afar off " in Jewish literature (the Hebrew letters are simply I, O, N, plainly the Greek ' Ionian '). These, and no doubt some of their predecessors, spoke various dialects of an Indo-European tongue. By now cheap iron had begun to supersede bronze in warfare, agriculture, and industry; and the later invaders from the North were horse-*riders* (looking like centaurs to their foes), not merely drivers of horses harnessed to chariots. In the Homeric poems the Achaean military chiefs are distinguished by their tall stature, their ' yellow ' hair, their ' grey ' eyes, their ' ivory-white ' or ' rosy ' skins: they must therefore represent Nordics from the North, or more probably (in view of their broadish heads as depicted by later sculptors) a mixed stock with a strong Nordic infusion. This is the physical type adopted for the Olympian Gods, the later heroes, the aristocrats, and the statuesque ideal. If further evidence were required, we have only to look at the coloured vases and the portrait-busts (of Socrates, Plato, and Pericles, for instance) to see what a very heterogeneous community the Athenians must have been about the time of which Galton speaks.

One or two geneticists have suggested that " the exceptional accomplishments of mongrel races like our own may have been due in part to ' heterosis ' " (i.e. " the ' hybrid vigour ' caused by the fact that in the heterozygotes certain characteristics are developed with greater intensity than in the recessive or pure dominants ")—a phenomenon whose importance in the human race has, so Penrose believes, been unduly overlooked (cf. *Eugen. Rev.*, XLI, pp. 23f.). But with the Greeks at any rate the ' racial qualities ', as Galton calls them, could be sufficiently accounted for by the cross-breeding, the recombinations, the wide variability, the progressive selection, the subsequent inbreeding and assortative mating. That the dictates of eugenics were not wholly strange to the Greeks themselves is shown by their stringent marriage-laws (notably in Sparta), the pride with which the various clans and families preserved their pedigrees, the widespread practice of exposing weakly infants, and above all by Plato's celebrated distinction between the classes of ' gold, silver, copper and iron ' and his frequent appeal to the analogy of the breeding-stud (*Rep.* 415 B, 459 A).

Cut off as the Greek cities were in their island homes and mountain valleys, it would have been impossible at that date to organize a Greek empire, like the older empires of Egypt or Mesopotamia. Athens itself, even at the climax of its fortunes, was distinguished from every previous civilization by quite appropriately be called the ' proletariat '[1]—each of the two features being a common and a natural sequel to any general rise in the standard of comfort; secondly, and in part an indirect consequence, " the decline in public esteem for men of high originality and enterprise ", leading to their ostracism, persecution, banishment, or death, and still more often to their voluntary migration.[2] In the case of Greece and Rome the inevitable outcome was, in Seeck's phrase, " eine Ausrottung der Besten ".[3]

Galton's favourite example is drawn from the closing phase of the Spanish Empire. Early in the sixteenth century Spain was already being drained of her finest and most adventurous blood by the expeditions to the New World. In the second half of that century under Philip II (" a man of second-rate ability ", says his biographer) the dungeons and *autos da fé* of the Inquisition destroyed many of the most brilliant and intellectual of his subjects; and those who survived usually did so by seeking shelter in some religious order and submitting to the rules of celibacy which it imposed. This enforced sterility was the factor on which Galton laid the greatest stress. Undoubtedly other causes contributed.

being at once non-monarchical and non-sacerdotal. It was the first state to establish government by consent—in theory a democratic republic, in practice an aristocracy. And the ultimate aim of Pericles himself was to draw together all the Hellenic communities into a kind of United States of Greece, with Athens as "the leader and school of her fellows". Perhaps his most appropriate epitaph would be the words of Landor: " He raised and rewarded every kind of merit " (*Pericles and Aspasia*, 1st ed., II, p. 297).

And so no doubt, as Dr. Isaacs argues, the peace, security and confidence which followed the rout of the Persian army, together with " the economic, social, and political circumstances of the time " were " *necessary* conditions for the remarkable intellectual achievements that followed ". But, as Galton would have maintained, they could not by themselves have constituted the *sufficient* conditions. There had also to be "the ability and the will of the people and above all of the people's leaders ".

[1] At Rome the *proletarii* formed the lowest of the citizen classes and were so called because " their only contribution to the state was their *proles* (i.e. their numerous offspring) ": cf. Cicero, *Rep.*, II, 22, 40. By the Julian laws of 17 B.C. and the Lex Papia Poppaea, passed a quarter of a century later, Augustus endeavoured to check the growing decadence of the patrician class by imposing penalties on bachelors, forbidding senators to marry below a certain rank, and granting substantial priviliges to those with three or more children. Nevertheless, as Tacitus observes, these and other measures proved a complete failure (*Annals*, II, 25). " *Raraque in hoc aevo qui velit esse parens*," was the poet's comment (*Nux*, 15, formerly attributed to Ovid). And Horace sums it up in his concluding lines (*Carm.*, III, 6):

" Aetas parentum pejor avis tulit
Nos nequiores, mox daturos
Progeniem vitiosiorem."

[2] At Athens the change begins even before the close of the Peloponnesian war. Socrates was executed, Themistocles ostracized, Aristotle obliged to return to a foreign court. Demosthenes in his *Philippics* comments repeatedly on the decadent spirit of the people. During the Roman period the ablest Greeks were deported or invited to Rome. And the later inhabitants of Greece were descended not so much from the citizens as from the far more numerous body of foreign slaves. Malaria and other epidemics hastened the decline. From the sixth century onwards there was a large infiltration of Slavs. The Ottoman rule introduced a further admixture of Turks: (originally Mongolian nomads, they had acquired from the Armenoid beauties of Asia Minor whom they swept into their harems a Levantine countenance: this, as we see in the Jews, is a physiognomy that tends to show Mendelian ' dominance ': the broad hairy face, with thick curved nose, which they share with the Turks, is not a ' Semitic ' trait as is popularly supposed). As a result of all these changes the population of Greece is today quite different from that of classical times: it is far more brachycephalic. " The only wonder," says Myres (*loc. cit.*, p. 27), " is that it is still possible to trace elements which are none of the admixtures, but apparently continuous in descent from . . . Hellenic times." To the Mendelian, however, it is hardly a " wonder ", but precisely what we should expect from the constant process of gene-segregation.

[3] *Geschichte des Unterganges der Antiken Welt*: J. L. Myres, ' Changes in Population in the Classical World ', *Eugen. Rev.*, IX, pp. 193f.

There was, for example, the unexpected influx of silver from the West, the equally unforeseen rise in prices as a result, and a consequent social upheaval. There were too the various events beyond the borders of Spain which ultimately brought about the alliance of France with the two chief seafaring nations—England and Holland; and, as it happened, each of the three countries at that time possessed an exceptionally shrewd and energetic leader. Before the century closed, Philip was beaten and bankrupt. But these very circumstances themselves depend in part on psychological factors. And thus, with certain minor reservations, most contemporary historians would, I think, accept Galton's account of the matter as in all probability containing a large element of truth.

In man no doubt 'mental evolution' differs profoundly from 'mental evolution' in animals, owing partly to the control he is able to exercise over his own environment and partly to the preponderant role played in his development by social conditions. Hence Galton's application of the Darwinian theory to human evolution requires some qualification. Nevertheless, since he wrote, an increasing amount of evidence has accumulated to show that the kind of qualities he had in mind—health, longevity, fertility, intelligence, energy, and stability of temperament—are all largely dependent on genetic factors. This means that genetic factors must inexorably limit what even the most favourable environmental conditions can achieve, and may themselves sometimes compensate for the lack of favourable conditions.

Moreover, although the *average* innate qualities of different 'races' differ but slightly,[1] an almost indiscernible superiority in the mean level may produce quite a large difference in the relative number at the upper end of the scale. What is still more important—the *range* of variation is itself liable to fluctuate appreciably from one community to another, and even within the same community at different times. Thus, in industrial civilizations mutant genes not only occur more frequently, they are also less frequently wiped out. Consequently populations living under such conditions show a much wider range of variation. Indeed I would venture to guess that the real handicap of the socalled primitive races has been, not their low average level, but their relative homogeneity.

From all this it follows that the mating system adopted by this or that nation or social class is quite as important as its initial genetic constitution. Frequently, it would seem, the first generation after racial or social crossing is marked by increased vigour, but this immediate effect rapidly disappears. In general, outbreeding tends to weaken adaptation to the present environment, but confers greater versatility with which to meet future environmental change; inbreeding tends to break up the total community into smaller castes or classes, and intensify their peculiarities, good as well as bad. The extremes are seen in the polygamous system of the Islamic conquerors and the rigid caste system of India. In view of the rapid changes occurring in the matrimonial customs of our own country, it is urgently desirable that studies of the apparent effects should be undertaken while the data are still available for observation and analysis.

Since the rediscovery in 1901 of Mendel's early work, both genetics and molecular biology have made astonishing strides. Far more is now known about the processes of human inheritance and the complex interactions between genetic constitution, embryological and physiological development, and conditions in the environment. Consider, for instance, the implications of one comparatively recent discovery, namely, the existence of marked differences in the frequency of different blood-types among different racial types. These happen to be quite unaffected by environmental agencies. Moreover, they appear to be

[1] The alleged inferiority of the negro races in innate general intelligence is not borne out by intelligence tests in which due allowance has been made for cultural differences. Even in the early American army tests the negroes in the Northern States did better than the whites in the Southern States. On the other hand, the black aborigines of Australia (a far more homogeneous stock than the negroes of Africa or the U.S.A.) have low I.Q.'s, and have failed almost entirely to absorb the education and culture of the European colonists—quite unlike the Maoris of the neighbouring islands of New Zealand: (one Maori even rose to cabinet rank).

correlated, not only with differences in the liability to certain diseases, but also with certain behavioural peculiarities, e.g., differences in the pronunciation of certain consonants. The correlation is so unexpected that (as Dr. Isaacs says) it needs a word or two of explanation.

It is recorded that before the Israelites were firmly established to the East of the river Jordan the ' men of Gilead ' fought with the ' men of Ephraim '; and, to distinguish friend from foe, they put to any suspicious fugitive some kind of question which would require in reply the Hebrew word for ' stream ' (*Shibboleth*). The Ephraimites pronounced it (as we should pronounce our own word) with a simple sibilant (*s*); the Gileadites, however, pronounced it (as a German might) with a ' broad ' fricative (*sh*).[1] There is an analogous difference in the pronunciation of dentals. Certain ethnic groups find it quite natural to pronounce *fricative* dentals (as in *faTHer*, *broTHer*, or *THree*); the rest substitute a *plosive* (as in *VaTer*, *BruDer*, *Drei*). Now if a map is made of this linguistic difference, the present frontier between the two coincides almost exactly with the 64·5 per cent contour-line separating Western and Southern regions of Europe in which the recessive O blood-type predominates from those in which the A and B types predominate.[2] Trifling as it may seem, this well established correlation plainly suggests that differences in blood-groups might provide serviceable ' ethnic markers ' for psychogenetic investigations. Other scientific discoveries suggest other modes of approach. A.I.D. (artificial insemination from a donor), for example, appears likely to become increasingly frequent; if so, the records—provided they are systematically compiled—should furnish useful empirical tests for various psychogenetic hypotheses. Thus it would now seem that genetic researches of the type that Galton demanded are by no means so impracticable as Dr. Isaacs and others have supposed. But at the present stage by far the most fruitful line of attack will be to carry out intensive studies of breeding systems and behavioural inheritance in animals.[3]

Among the many geneticists who have lent their support to Galton's conclusions the most eminent is Sir Ronald Fisher. More particularly he has succeeded in combining the genetic approach with the biometric, and has shown how modern statistical techniques can be adapted to check the theoretical assumptions involved. In his chapters on the eugenic

[1] *Judges*, XII, 6. Here the ' ethnic implications ' about which Dr. Isaacs asks are largely guesswork. It is commonly supposed that the legend embodies recollections of Abrahamic rather than Mosaic traditions. It would seem that about the 4th millennium an 'Alpine ' stock (doubtless related to the Indo-European people who, according to the Boghaz-keui inscription, later entered from the North—the ' Hittites ' of Gen. XXIII) had descended from the high plateaux around Mount Ararat, settled first in Harran (the original home of Abraham and his father), then worked their way towards ' Ur of the Chaldees ', and later into Canaan, having meanwhile adopted a mispronounced Semitic speech. In that case the Habiru mentioned with the Hittites in the El Amarna tablets (c. 1380 B.C.) would be a mixed Armenoid stock. It would seem that they were later challenged by nomadic invaders (of a type related to the modern Bedouin) whose native tongue was Semitic and who had come up from the Arabian desert in the South (some perhaps from Egypt after the expulsion of the Semitic ' Shepherd-Kings '). This would explain the difference in pronunciation by an ethnic difference (cf. J. Garstang, *Joshua and Judges*). The attempts of the Greek (LXX) and Latin (Vulgate) translations of the verse cited above to illustrate the difference further exemplify the point, for neither language possesses the sound *sh*. A related difference, also associated with a difficulty in the pronunciation of sibilants, is seen in the familiar division of the Indo-European languages into the ' centum ' and the ' satem ' branches; originally these two seem also to have been correlated with a broad ethnic difference. A similar test was adopted during the massacre of the Sicilian Vespers (31 March, 1282); the French were made to betray themselves by their sibilant pronunciation of *ceci e ciceri*.

Julian Huxley deplores the fact that " the implications of the new knowledge (supplied by post-Mendelian genetics) have not been incorporated in anthropological writings " (*We Europeans*, p. 63); and my reason for elaborating the foregoing argument is not merely to reply to Dr. Isaacs' inquiries (p. 77) about ' ethnic implications ', but also to suggest that a Galtonian study of the evolution of the Jewish peoples would prove even more illuminating than the study of the Greeks.

[2] Cf. C. D. Darlington, ' The Genetic Component of Language ', *Heredity*, I pp. 269–286.

[3] See J. L. Fuller and W. R. Thompson, *Behaviour Genetics*, 1960.

problem, after examining the various causes adduced by previous writers to explain " the decay of every civilization previous to our own ", he himself concludes that " the evidence examined leaves little doubt that the most powerful selective agency in civilized man is that acting upon mental and moral qualities by way of the birthrate ".[1] Since Fisher wrote, the other two factors chiefly stressed by historians—persecution and migration—have (as Dr. Isaacs observes) also been operative on an extensive scale; and to the depletion thus resulting several writers have recently ascribed " the marked deterioration in the quality of German post-war contributions to the various sciences, as well as other more familiar results " (p. 78 below). But here I agree with him that environmental factors have also cooperated, so that " we are scarcely justified in looking in that direction for definite verification ". It is always precarious to rely on mere deductive arguments to reach solutions to biological or sociological problems. At present, however, the nearest approach to direct confirmatory evidence that I know of is the decline in tested ability among school children in certain English villages during the past fifty years, where there has been either a marked change in the differential birthrate or an exodus of the brightest teenagers to the neighbouring towns. But, when all is said, the most important conclusion to be drawn is that on which Galton always laid the greatest stress—namely, the pressing need for more extensive and carefully planned research.[2]

I may sum up my own provisional conclusions as follows. Great changes in national character and culture may unquestionably occur, without any corresponding change in the innate mentality of the people as a whole, purely as a result of contact with other nations or of internal social or intellectual changes. So far as the rise and fall of nations is the result of genetic influences, they are due, not so much to any racial change, but rather to changes in the relative fertility of its leading members or its leading classes; and such changes can only operate favourably when there is already a wide range of individual variation on which the selective processes can work. Thus neither heredity alone nor environment alone but the interaction of the two forms the really effective agency.

[1] R. A. Fisher, *The Genetical Theory of Natural Selection*, 1930, p. 209. Fisher places special weight on the fact that an able and energetic individual, who is also infertile or at any rate refrains from marriage and the production of children, is far freer to work his way up from a lower socio-economic class to a higher. As Bacon long ago observed, " he that hath wife and children hath given hostages to fortune, for they are impediments to great enterprises either of virtue or mischief; certainly, the best works have proceeded from unmarried or childless men, which have married and endowed the public " (*Essay* VIII).

Galton's illustration remains the most striking. In the past able and ambitious individuals have often sought to hasten their own advancement by marrying wealthy heiresses; peers or their sons did the same, frequently in the hope of restoring the family fortunes. But a daughter only becomes an heiress because her parents have no surviving sons. And this infertility is apparently inheritable. After examining a long list of peers, some newly created, others of ancient date, Galton found that, when the line became extinct, this had very commonly followed on a marriage with an heiress. Taking 100 heiresses who were wives of peers and comparing them with 100 peeresses taken at random, he found that whereas the latter produced on an average 3·4 sons, the former produced less than 2·1. (As we have seen, one of the stocks from which Galton himself was descended was apt to die out in the male line and Galton himself was childless: Pearson infers that it was this which directed Galton's attention to the whole subject of infertility.)

[2] These inadequate and somewhat disjointed comments are intended merely to answer the criticisms urged by Dr. Isaacs and others against Galton's general position, largely, so it seems to me, as a result of misunderstanding. They are not put forward to support any eugenic theory of my own. Those who wish for a more systematic review of the problems may refer to F. Osborn, *Preface to Eugenics*, 1951, and T. Dobzhansky, ' The Biological Concept of Heredity as Applied to Man ', ap. *Nature and Transmission of the Genetic and Cultural Characteristics of Human Population*, Milbank Memorial Fund, 1957. For the views of psychologists and geneticists regarding the relation between intelligence and fertility, see the *Memoranda presented to the Royal Commission on Population*, H.M. Stationery Office, 1950. For the views of anthropologists and historians see G. V. de Lepouge, *Race et milieu social* (1909); E. Pittard, *Les races et l'histoire* (1924); C. S. Coon, *The Races of Europe* (1939); A. J. Toynbee, *The Study of History* (1939).