12 Nineteenth-Century Bases of Psychology

Chapter Contents

This chapter considers three nineteenth-century scientific movements that had a direct impact on both the founding of psychology and its subsequent expression in the twentieth century. First, in physiology, research on nervous activity provided an empirical basis for many human functions that were previously considered functions of the mind. Second, a German development called psychophysics attempted to find the quantitative basis for the mind–body relationship, but it went beyond Herbart's psychological writings by employing an empirical approach. Finally, the writings of Charles Darwin in Britain affirmed a theory of evolution based on the empirical evidence of natural selection. All three movements helped to establish the formal study of psychology.

Advances in Physiology

Empirical research in physiology made important strides in the nineteenth century. The study of nervous activity, sensations, and brain physiology confirmed the benefits of careful, systematic, empirical strategies. For psychology, these benefits pointed to the possibility of elucidating the physiological basis of mental operations.

Physiology of the Nervous System

The distinction between sensory and motor nerves was independently demonstrated by the experimental work of Charles Bell (1774–1842) and François Magendie (1783–1855). Bell was born in Edinburgh and achieved fame as an anatomist in London; Magendie was a widely esteemed professor and member of the French Academy. Their collective work, encapsulated in the Bell–Magendie law, was based on their discovery that the posterior roots of the spinal cord contain sensory fibers only, whereas the anterior roots contain motor fibers. Thus, neural fibers were no longer considered either "hollow tubes" transmitting "spirits" of activity or all-encompassing fibers communicating both sensory and motor functions through "vibrations" arising from sensory stimulation. Rather, neural fibers were specific in function, and neural conduction seemed to occur predominantly in one direction.

The work of Bell and Magendie received systematic elaboration in the writings of Johannes Müller (1801–1858), who set the tone for nineteenth-century physiology. His exhaustive *Handbuch der Physiologie des Menschen* (Handbook of Human Physiology, 1833–1840) became the classic compilation of contemporary physiology. After receiving his doctorate from the University of Bonn in 1822, Müller served there as a professor until 1833, when he was called to be professor of physiology at Berlin. Many of the foremost European physiologists of the nineteenth century were his pupils, and still more were certainly influenced by the *Handbuch*. Based on the work of Bell and Magendie, Müller fully articulated the doctrine of specific nerve energies. He described the specific qualities of neural transmission, formulating them under ten laws. The major implication of Müller's doctrine is the explicit statement that our awareness is not of objects, but rather of our nerves themselves. Accordingly, the nervous system serves as the intermediary between sensed objects and the mind. Müller asserted that five kinds of nerves each impose their own quality on the mind. As a physiological parallel of Kant's philosophical notion of categories of the mind, Müller's work stimulated the study of localization of functions in the brain, which is considered in the following sections.

The understanding of sensory physiology took a major step when neural conduction was discovered to be basically an electrical process, finally putting to rest the traditional view of nerve fibers containing "animal spirits." We already noted in Chapter 10 that Gralath of Leiden was able to store electrical charges in a series of jars. An Italian physiologist, Luigi Galvani (1737–1798), used Leiden jars as an electrical source to do the classic experiment eliciting reflex action in the leg of a frog with a partially intact spinal cord. Galvani correctly concluded that nerves are capable of conducting electricity, although in attempting to fit his discovery into existing views, he thought he had isolated a unique substance – "animal electricity" – which is transported via a fluid from the nerve to the muscles. It was a student of Johannes Müller, Emil Du Bois-Reymond (1818–1896), who broke away from the traditional view of "animal spirits" and established the modern basis of neural transmission by describing the electrical properties of the neural impulse.

The speed of a nerve impulse was measured by another of Müller's students, Hermann von Helmholtz (1821–1894), whom we consider later in this chapter. In his *Handbuch*, Müller had acknowledged, although somewhat skeptically, one of the major implications of the "animal spirits" view of neural transmission – namely, the speed of a nerve impulse is too rapid to be observed and studied empirically. However, Helmholtz devised a method of measuring temporal duration between the application of an electrical stimulus to a frog's nerve and the twitch of the muscle. In the frog he found reaction times of 0.0014 second and 0.0020 second for 60 mm and 50 mm of nerve fiber, respectively, yielding limits of 42.9 and 25.0 meters per second. Using the same method to measure reaction time in humans, Helmholtz stimulated a subject on the toe and thigh and calculated differences in reaction times. He found that the rate of transmission for sensory impulses is between 50 and 100 meters per second. Although others, such as Du Bois-Reymond, would later report more accurate calculations, Helmholtz had succeeded in empirically demonstrating neural transmission, increasing faith in the efficacy of empirical science. Moreover, because Helmholtz reliably measured the effects of stimulation through the overt behavioral responses (that is, the reaction time) of subjects, the reaction time experiment served as a prototype of empirical psychology.

Physiology of the Brain

Perhaps the most dramatic reflection of the major advances in brain physiology during the nineteenth century occurred in 1906 with the joint award of a Nobel Prize to an Italian neurologist, Camillo Golgi (1844–1926), and a Spanish anatomist, Santiago Ramón y Cajal (1852–1934). In 1873, Golgi published a paper reporting his use of silver nitrate to stain nerve cells, revealing under a microscope the structural details of nerves. Ramón y Cajal, a professor of neuroanatomy at the University of Madrid, later used this staining technique to make his discovery of the neuron, the basic unit of the nervous system. Their work, at the end of a century that began with the prevailing view that the workings of the nervous system were analogous to those of the circulatory system, demonstrated the value of empirical strategies in the study of nervous activity.

At the beginning of the nineteenth century, the dominant interpretation of brain functions was contained in the doctrine of **phrenology**, expressed by Franz Joseph Gall (1758–1828) and his student Johann Gaspar Spurzheim (1776–1832). To a large extent, phrenology and similar movements in brain physiology were a logical consequence of the mentalistic model embodied in the "faculty" psychology championed by Wolff and Kant. Specifically, phrenology attempted to find a physiological localization of mental faculties. Gall began as a lecturer in Vienna, but in 1800 was pressured into leaving by the Austrian government and spent his remaining years in Paris. Gall and Spurzheim suggested that there are 37 mental powers corresponding to the same number of brain organs, and the development of these organs causes characteristic enlargements of the skull. Accordingly, they developed a pseudoscience that claimed extreme localization of brain functions. Phrenology held that the degree of a mental faculty or trait possessed by an individual is determined by the size of the brain area controlling that function and that this can be evaluated by measuring the overlying skull area.

Gall's phrenology forced the question of brain localization into the forefront of physiological investigation. One scientist whose work led him to reject phrenology and substitute better evidence of brain localization was Luigi Rolando (1773–1831). In 1809, Rolando published his research efforts in Italy, and in 1822 they were reviewed in French. Using pathological observations, Rolando argued that the cerebral hemispheres are the primary mediators of sleep, dementia, melancholia, and mania. Sensory functions were localized in the medulla oblongata. Although Rolando's experiments were primitive, he found that electrical stimulation elicited more violent muscle contractions as the stimulation point was moved to higher brain centers. Similarly, Pierre-Paul Broca (1824–1880), a French physician, performed a postmortem examination of a man who had speech aphasia. Broca found damage in a specific area of the frontal cortex (now called Broca's area), which he interpreted in support of the thesis of localization of function by describing the area as the physiological basis of expressive language. Karl Wernicke (1848–1905), a German physician, soon discovered that damage to a certain area of the left temporal cortex (now called Wernicke's area) resulted in deficits in receptive language or language comprehension, further supporting the brain localization thesis.

The study of brain physiology took on definitive form from both the precise methodology and the coherent interpretations offered by Pierre Flourens (1794–1867). After studying sensory physiology in Paris, Flourens secured a professorship in comparative anatomy and won election to the French Academy for his clear and concise refutation of phrenology, summarized in *Examen de la Phrénologie* (An Examination of Phrenology, 1824).

Rather than relying on pathological clinical evidence observed during postmortem examinations, Flourens perfected the more controlled method of extirpation. Essentially, in this procedure an area of the brain of a living animal is isolated, then removed surgically or destroyed without damaging the remainder of the brain. After recuperation, the animal is observed for loss of function and recovery of function. Flourens assumed that six separate areas exist in the brain and, using his surgical skills, was able to identify the important functions of each area:

1. *Cerebral hemispheres*: willing, judging, memory, seeing, and hearing
2. *Cerebellum*: motor coordination
3. *Medulla oblongata*: mediation of sensory and motor functions
4. *Corpora quadrigemina* (containing inferior and superior colliculi): vision

errors, discrepancies between stimulus intensity and perceptual strength, and uncaused sensory experiences, were not random. Rather, they were governed by the systematic relationship between the structure of the eye and the neural connection to the brain. In 1825, he published his observation, known as the Purkinje effect, that the relative luminosity of colors in faint light differs from that in full light. This difference between scotopic and photopic vision was later explained by the separate mediation of rods and cones of the retina. Purkinje also noted the inability to differentiate colors in the periphery of the retina.

Others, such as the celebrated German romantic poet and dramatist Johann Wolfgang von Goethe, had made similar self-observations of perceptual illusions. As a scientist, Purkinje saw these **phenomena** in terms of their physiological value. He proposed a corresponding objective, physiological basis for all subjective sensory phenomena, and showed how these subjective phenomena may be used as an appropriate tool to explore the objective bases. Thus, Purkinje admitted a method of self-observation or self-description as a valid investigative approach. Moreover, he suggested several procedures for its utilization. Purkinje's substantial contributions, as well as his methodological approach, were recognized by later psychophysicists and incorporated into one of the first formal models of psychology.

Purkinje also worked extensively in neurophysiology, as reflected by his identification of certain cells of the cerebellum (Purkinje cells), and in the structure of the heart (Purkinje fibers). His recognition of the need for experimentation and self-observation in physiological research made a great impact on the methodological direction of psychology; he allowed for the study of subjective experience in addition to more objective physical and physiological components in the understanding of sensory processes. We now consider the movement called psychophysics, an immediate precursor of modern psychology, which owed a debt to Purkinje.

Psychophysics

The label *psychophysics* is given to a type of sensory physiology that emphasized subjective experience in the study of the relationship between physical stimuli and sensations. As a group, psychophysicists examined sensations from several perspectives. They considered sensations as a reflection of the mind–body problem, rather than as a situation for anatomical and physical study alone. At the same time, however, these psychophysicists were not psychologists, because they did not seek a new and comprehensive discipline. Rather, they remained inside the traditional disciplines of their training: physiology, physics, or natural philosophy. Indeed, only with hindsight knowledge of the subsequent emergence of psychology does psychophysics take on coherence as a movement. Nevertheless, psychophysics served as a critical transition between the study of the physiological and physical components of sensation and the emergence of psychology itself. Thus, the scholars of the psychophysical movement were the immediate precursors of modern psychology.

Ernst Heinrich Weber (1795–1878)

The first person who may be categorized as a psychophysicist, Ernst Heinrich Weber, was professor of anatomy and physiology at Leipzig from 1818 until his death. The University of Leipzig became the dominant institution for both the psychophysical movement and the emergence of a psychology modeled after the natural sciences. Weber's contributions included an exhaustive investigation of the sense of touch. He established a methodological orientation that seemed to demonstrate the possibility of quantifying mental or psychological operations.

His major work in psychology, *De Tactu: Annotationes Anatomicae et Physiologiae* (On Touch: Anatomical and Physiological Notes), was published in 1834 and contained extensive experimental work. He distinguished three manifestations of the sense of touch: temperature, pressure, and locality sensations. Temperature was dichotomized into positive and negative sensations of cold and warm, which Weber felt were analogous to the light and dark sensations of vision. In his investigations of pressure, Weber developed a methodological innovation known as the two-point threshold. Briefly, he used a compass with two points and attempted to measure cutaneous sensitivity by the smallest detectable distance between the two points that could be sensed by a subject. Weber found that this threshold of detectable difference between the two points varied with the places of stimulation, a variation he explained by postulating differential densities of nerve fibers underlying the skin's surface. This method led him to a study of weight discrimination and eventually to the formulation of "Weber's law," named for him by his colleague Gustav Fechner, who is considered in the following section. Weber found that the smallest detectable difference between two weights can be expressed by the ratio of the difference between the weights relative to the absolute value of the weights, and that this ratio is independent of the absolute values of the weights. He extended his research to other senses and found general validity for the ratio of the smallest detectable difference between two stimuli. The last touch sensation, locality, was viewed by Weber to be more than a sensory dimension. Rather, he believed locality was more dependent on perception, which he interpreted as higher mental activity.

Weber succeeded in using a quantified approach to sensations, an approach that was adopted by his successors. However, in his interpretation of mental action on these sensations, he relied on the prevailing philosophical system of Germany – namely, Kant's views of the mind. In other words, Weber viewed perceptions as governed by mental categories of time and space, and did not speculate further.

Gustav Theodor Fechner (1801–1887)

The major proponent of psychophysics, Gustav Theodor Fechner attempted to explore more fully the relationships between sensations and perceptions. He labeled this movement through his *Elemente der Psychophysik* (Elements of Psychophysics, 1860), which was designed to be an exact science of the functional relations between the body and the mind. Moreover, Fechner's psychophysics was constructed as an attack on materialism. This goal is of interest because of the implied assumptions behind his psychophysics. Specifically, he did not believe that the notions of science and the mind are necessarily mutually exclusive; there is no compelling reason to reduce the mind to materialism (as in physiology) in order to study mental operations scientifically. Rather, in the tradition of German philosophy, he acknowledged the essential activity of the mind and proposed an empirical science of the mind that allows the relative increase of bodily, sensory stimulation to serve as the measure of the mental intensity of experiences.

Fechner was born in a small village in southeastern Germany, the son of the local church pastor. At age 16, he began to study medicine at the University of Leipzig and received his degree in 1822. Fechner's interest shifted to physics, and he remained in Leipzig to study, supporting himself by translating, tutoring, and giving occasional lectures. In 1831, he published a paper on the measurement of direct current, using the relationships published by Georg Ohm in 1826.

Fechner was appointed professor of physics at Leipzig in 1834, and his future seemed secure. His interests began to move toward problems of sensations, and by 1840 he had published research on color vision and subjective afterimages. At about this time Fechner had what might be called today a nervous breakdown. He had overworked, exhausting himself, and he also damaged his eyes by gazing at the sun during his research on afterimages. Fechner's collapse seemed total, and he resigned his position at the university to live in seclusion for three years.

Fechner recovered, but his illness and confinement had a profound effect on him. He emerged from his crisis committed to the spiritual aspects of life, and renewed his religious convictions. He was convinced of the existence of both mind and matter, and believed that the materialism of science, exemplified by prevailing sensory physiology, is a distortion. For the rest of his life, he published on wide-ranging topics. In addition to psychophysics, he attempted to formulate an experimental aesthetics, and even proposed a solution to the problem of determining the shape of angels.

His contributions to psychophysics are his most important works. After publishing two short papers on the subject, his *Elemente* appeared in 1860. This work was not widely recognized at first, but did attract the attention of two important leaders in German psychology – Helmholtz and Wundt. Any overview of Fechner's psychophysics must begin with the concept of *limen*, or threshold, which originated with Herbart and was developed by Weber. The notion of threshold is a quantitative expression that has two applications. The first usage refers to the minimal amount of physical energy needed in a stimulus for it to be detected by the observing subject, which was termed the *absolute threshold*. The second usage refers to the minimal amount of change in physical energy required for sensory detection.

Fechner began with the relationship expressed in Weber's law:

$$\frac{\Delta R}{R} = K$$

Here, using the German symbols (R = *Reiz* = stimulus), Fechner expressed Weber's findings that the ratio of the change in stimulus value (ΔR) to the absolute value of the stimulus (R) is equal to a constant. This constant is a measure of the second usage of threshold, which Fechner called the *just noticeable difference* (JND, or k) in stimulus intensity detected by the subject. Fechner then related the magnitude of an experienced sensation (S) to the magnitude of the stimulus using the JND (k), by the following relationship:

$$S = k \log R$$

Quadrant B of Figure 12.1 shows Fechner's empirically derived function for the relationship between **the magnitude of the stimulus value** (ordinate axis) and the strength of the sensation (abscissa). It is possible to extend Fechner's reasoning beyond his empirical demonstration, and quadrants A, C, and D of Figure 12.1 attempt to represent some of the hypothetical relationships within

Fechner's approach. For example, the relationship between stimulus intensity and sensation that could occur in quadrant A would describe the non-detection of stimuli present, which relates to the sub-threshold of attention. Quadrant C depicts possible sensory experiences in the absence of physical stimulation, and quadrant D describes nonsensory experiences of non-stimuli. The former (C) might define hallucinations; the latter (D) could be a definition of dreams. Although this interpretation may be pushing Fechner's conceptualization beyond his intention, it is fascinating that his views of the relationship between sensations and stimuli include a complete framework within the active model of the mind prevalent in German philosophy. Indeed, Fechner was very much a part of the intellectual climate of his contemporary Germany.

Fechner proposed three fundamental methods to determine thresholds. The first was called the *method of just noticeable differences*, wherein the subject is asked to detect or respond to minimal change in stimulus values. The second was called the *method of right and wrong cases*, or the *method of constant stimuli*, in which the subject has to judge repeatedly which of two stimuli is the more intense. The third, the *method of average error*, requires subjects to adjust stimuli until they are equal. These techniques effectively estimate the major variables in psychophysical studies, and similar procedures are still employed in psychological investigations.

To judge by Fechner's stated goals of anti-materialism, he probably would not be very pleased with his own contributions to psychology, which have been

Figure 12.1 The possible relationships between stimulus intensity and the magnitude of sensation. The abscissa and ordinate axes are ordered in arbitrary units. Quadrant B shows the empirically derived relationship between the intensity of a stimulus and the magnitude of the sensation described by the function $S = k \log R$. In quadrant A, the non-detection (negative sensation) of a stimulus value would appear. Quadrant C describes a sensation in the absence of a stimulus. Quadrant D shows the non-detection of a non-stimulus.

largely methodological. However, without trying to begin a new disciplinary study, he established a systematic area of investigation that no longer fitted neatly into sensory physiology or physics. Others who did intend to define a new scientific discipline of psychology recognized the significance of Fechner's psychophysics and readily adopted it.

Hermann von Helmholtz (1821–1894)

Hermann von Helmholtz was one of the most distinguished scientists of the nineteenth century, achieving remarkable findings in physiology and physics as well as in psychology. We have already noted his measurement of the speed of a nerve impulse and his studies in optics which, through careful experimentation,

Evolution

The publication of Charles Darwin's *On the Origin of Species* (1859) represented for science a triumph of advances that began with Copernicus. The questioning of theologically based authority started with Copernicus and continued as various other thinkers chipped away at the province of theology throughout post-Renaissance development. The sciences of physics, physiology, and chemistry and early empiricist psychology provided reliable answers to the perplexing issues of life without reverting to explanations involving divine mediation. Darwin's theory of evolution, although not a complete innovation, provided convincing evidence that shocked theologians. First, if humans and apes derive from common ancestry, then the traditional privileged position of humanity, created in God's image, is unwarranted. Second, if all life evolved by the principle of natural selection, the role of God as the final cause of creation is unnecessary. For psychology, Darwin's theory of evolution represented the third movement of the nineteenth century (the other two being the sophistication of physiological research and the development of psychophysics) that not only allowed the formal study of psychology to emerge as a discipline but, indeed, made its establishment unavoidable and compelling.

Ψ Charles Darwin (1809–1882)

We have already seen that Erasmus Darwin suggested an evolutionary concept in eighteenth-century England. His grandson Charles Darwin was the fifth child of Robert Darwin, a successful physician in Shrewsbury in western England. In 1825, Charles was sent to the University of Edinburgh to study medicine, but the practicalities of clinical medicine were not to his liking. However, during his stay at Edinburgh, Darwin was exposed to the evolutionary teachings proposed by the French naturalist Jean Baptiste Pierre Lamarck (1744–1829). Briefly, Lamarck argued that changes in animals occur through the efforts of the species to adapt to its environment; for example, giraffes adapt to better food sources by developing longer necks. Thus, the acquired characteristics of environmental adaptation are passed from generation to generation. While at Edinburgh, Darwin was also introduced to the methodology of naturalistic biology and geology.

In an effort to find a new career for him, Darwin's father sent him to Cambridge University to prepare for the Anglican clergy. Darwin received his degree in 1831, and through his Cambridge contacts secured an invitation to join an expedition sponsored by the British Admiralty. He was to serve as an unpaid naturalist in a survey of the coasts of Patagonia, Tierra del Fuego, Chile, Peru, and some of the Pacific islands. After overriding objections from his family, Darwin set sail on December 27, 1831, aboard HMS *Beagle*, under the command of Robert Fitzroy.

The five years of the voyage of the *Beagle* had profound effects on Darwin, and he used the observations and evidence collected during those years as the basis for his subsequent writings. The places visited by the *Beagle* – from the Cape Verde Islands off the west coast of Africa to the isolated Galápagos Islands in the Pacific Ocean off South America – provided not only a living laboratory for Darwin but also a preserved history of tremendous significance. He was able to journey on land and observe primitive human societies and innumerable species of animal life. His work during these five years provided convincing botanical, geological, and anatomical evidence to support the theory of natural selection.

Darwin's theory of evolution differed from Lamarck's on several important points. Darwin proposed that, first, species variation over time results from chance and not by the adaptive effort of animals. Second, natural selection is an inherent struggle for species survival, a view Darwin found consistent with the economic views of the British philosopher Thomas Malthus (1766–1834). Darwin's argument for evolution by natural selection relied on several compatible lines of evidence. He postulated that the numbers of members of species are relatively constant, but also noted the overproduction of pollen, seeds, eggs, and larvae, leading him to conclude that there is a high mortality rate in nature. In addition, he gathered ample evidence to prove that all members of a given species are not identical but, rather, show variability along anatomical, behavioral, and physiological dimensions. He concluded that in the same species some members are better able to adapt than others, and they will tend to have more offspring, who will in turn reproduce. Finally, he pointed to the resemblance between parents and their offspring, concluding that subsequent generations will not only maintain but also improve their adaptability to environmental conditions. As environmental conditions vary, the criteria of natural selection differ, and over time, divergent generations gradually arise from common ancestry. For Darwin, the missing piece of his evolutionary theory was the exact nature of hereditary transmission, which he could not supply. A rather obscure Czech monk, Gregor Johann Mendel (1822–1884), completed Darwin's theory through his botanical experiments showing the inheritance of particular characteristics, and thus founding the study of genetics.

The implications of evolution by natural selection for psychology were addressed in two later works of Darwin, *The Descent of Man* (1871) and *The Expression of the Emotions in Man and Animals* (1872). Darwin argued that the essential difference between humans and the highest primates is one of gradation, not quality. He pointed to the full gamut of activities, ranging from self-preservation to cognition to emotions, shared by all animals, including humans. Moreover, Darwin included the evolution of moral attitudes in his framework, pointing out the survival value of moral development. An admirer of Darwin, George Romanes (1848–1894), pursued the comparative value of cross-species study in his work *Animal Intelligence* (1882). Romanes presented evidence to establish common dimensions of evolution between human and infrahuman activity and offered a primitive form of comparative psychology. The methodology of Romanes's work was somewhat loose and anecdotal in nature, leading to the criticism that his conclusions were anthropomorphic. Another early comparative psychologist, Lloyd Morgan (1852–1936), attempted to counteract the anthropomorphism of Romanes by urging a parsimonious convention, known as "Lloyd Morgan's canon," in comparative studies: If a particular animal behavior could be explained by any one of several functions, the simpler, and presumably phylogenetically lower, explanation should be chosen. The validity of a comparative approach to psychological study was firmly established in Britain as a direct by-product of Darwin's teachings.

Herbert Spencer (1820–1903)

A more comprehensive view of psychological studies with social implications derived from evolutionary theory was contained in the writings of Herbert Spencer. Spencer has been described as an "evolutionary associationist." His writings on the association of ideas, advocating associations as the principal mediating experiences, place him clearly in the British empirical tradition. Moreover, Spencer's writings come almost full circle to the Ionian physicists of ancient Greece, who were searching in nature for the basic substance of life that accounts for change. In a similar manner, Spencer used evolution as the basic principle and applied this interpretation of change in life to the individual in society.

Spencer stressed that the relations between feelings are based on the association principle of similarity. His evolutionary perspective led him to suggest that associations made repeatedly are passed along through heredity. Accordingly, Spencer's view of the inheritance of acquired associations led him to conclude that instincts become an inherent part of our ethnic and racial heritage. Indeed, it was Spencer, in applying evolution on the human social level, who coined the phrase "survival of the fittest," which not only distorts Darwin's theory but ultimately falls into redundancy. Spencer's evolutionary associationism, for all the empirical aura embodied in the concept of associationism from the British tradition, clearly supports a perspective more akin to the German philosophical position because of its proposal for inherited dispositions.

Francis Galton (1822–1911)

A final figure in the nineteenth-century evolutionary context of Britain was Francis Galton. Both Darwin and Galton were grandsons of Erasmus Darwin, the former through Erasmus' first wife and the latter through his second wife. Galton's primary interest was human evolution and the inheritance of specific traits. Surely, his own family offered a ready example of the inheritance of intelligence. His two major works of psychological significance were *Hereditary Genius* (1869) and *Inquiries into Human Faculty and Its Development* (1883). Both works examined the inheritance of mental abilities with the goal of racial improvement. Indeed, the latter book took on an intense fervor as Galton argued the benefits of a belief in the attainment of human progress through evolutionary theory at the expense of religious approaches to human betterment.

Galton was a person of many talents, and his time spent in psychological inquiry was so significant that many psychologists point to him as the founder of experimental psychology in Britain. Perhaps because of the way in which nineteenth-century British philosophy accommodated psychological inquiry, the founding of modern psychology as a discipline separate from philosophy is looked upon as a German event. That is, British "natural philosophy" fully accommodated the work of Galton, so that a separate discipline of psychology was not compelling. In contrast, the separation of psychology from the German philosophical establishment was needed in order for psychology to advance despite a more "hostile" climate within German philosophy. In this context, Galton's role as an early advocate of psychology tends to be overlooked. However, his methodological rigor and his emphasis on long-term adaptation in terms of species improvement had an impact on early American functional psychology. This is described in Chapter 14.

To assess human abilities, Galton developed a methodological strategy that rested on the statistical analysis of mental tests. The tests were designed to measure individual achievement on mental exercises; they were brief to permit a wide sampling of subjects. Galton placed great emphasis on the measurement of individual differences, and attempted to study systematically varieties of mental activities ranging from motor behavior to mental imagery. Later, he developed a variety of devices to measure such characteristics as olfactory discrimination and space perception. He opened a laboratory where people could pay a small fee and receive a battery of tests, enabling him to sample over nine thousand people along many dimensions of intellectual and motor performance.

Galton started a movement in psychology that emphasized the value of testing and an associated statistical approach to defining population trends. This movement gained momentum at the beginning of the twentieth century, when psychologists, particularly in France and America, began to use mental testing on an increasingly wide scale. Moreover, Galton demonstrated the practicality or utility of translating Darwin's views on evolution from a biological abstraction into a mechanism for bettering society.

In summary, three nineteenth-century developments – neurophysiology, psychophysics, and evolutionary theory – together created an intellectual climate that demanded the founding of the new discipline of psychology. These movements were the immediate precursors of psychology and overlapped with the early development of modern psychology. We next return to Germany, where the volatile intellectual climate of the nineteenth century produced the foundation of modern psychology, presented to the world in the context of two opposing models of psychological inquiry.

Chapter Summary

Three movements in the nineteenth century formed the intellectual background from which psychology emerged as a discipline separate from the natural sciences and philosophy. In physiology, great advances were made in the understanding of the nervous system. The specific functions of nerve fibers were described by Bell and Magendie. Müller's systematic analysis of neural conduction led researchers such as Du Bois-Reymond and Helmholtz to describe the nature of the nerve impulse. As a reaction against Gall's phrenology, the localization of brain functions was studied through neuroanatomy and histology, reaching a culmination in the works of Flourens and Sherrington. The strides in physiological investigations were combined with advances in knowledge of physics to examine sensations, and Young, Helmholtz, and Müller all contributed theories of sensory processing. The methodological integrity of subjective sensory experience was justified by Purkinje.

The second nineteenth-century intellectual backdrop to modern psychology was psychophysics. This movement differed from sensory physiology by