

Arnold L. Gesell: The Paradox of Nature and Nurture

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Arnold Gesell (1880–1961) has had an important and lasting impact on the field of developmental psychology. He is best remembered for his developmental norms, which were acquired from decades of detailed observations of infants and children and are still the basis of most early assessments of behavioral functioning. Gesell's influence as a theorist is less direct. His maturationism quickly lost favor in the intellectual climate of Piaget, behaviorism, and information-processing approaches. Nonetheless, nativism is still a dominant theme in contemporary developmental studies in the guise of neural determinism, innate knowledge, and genetic studies. Gesell is characterized as a man of paradoxes and contrasts. Although he acknowledged the contributions of the environment, he denied its agency. Although he was devoted to children and their welfare, he assigned their individuality to biological destiny. And although he remained a steadfast maturationist, he prefigured other more dynamic views of development.

Arnold Lucius Gesell (1880–1961) stands as a giant in the field of developmental psychology. He pioneered the scientific observation of infants and children through innovative and technically sophisticated methods for collecting a vast archive of behavioral data. He published prodigiously over four decades to an enormous audience of psychologists, educators, physicians, policy makers, and other social scientists. His works have been translated into more than 20 languages and continue to be widely cited in scholarly books and journals. Through his popular books and columns, his name became a household word. He introduced a wide public to the science of child rearing and allowed for his successors, Benjamin Spock and Berry Brazelton, to become cultural icons. Gesell popularized the practice of developmental testing, with reverberations to this day in pediatricians' offices and school clinics. He was an active crusader for child welfare and for humane and child-centered educational practices, especially for developmentally handicapped children. And from his earliest writings, Gesell was a consummate developmental theorist. In its own terms, his theory was comprehensive, coherent, and informed by the best biological science of his day. Although he remained a steadfast maturationist, he had a sophisticated understanding of developmental processes and prefigured many dominant themes of modern developmental theory.

Yet a survey of contemporary developmentalists in academics or clinical practice would reveal few acknowledged Gesellians, in contrast to many who might claim an intellectual heritage from Piaget, Vygotsky, Erikson, Lewin, or E. J. Gibson. There is no chapter on Gesell in a recent textbook on develop-

mental theories, and scant mention in the text (Miller, 1989). Are the man and his work forgotten? Or has he been relegated, like Watson and the behaviorists, to extreme positions of the past, straw men in our introductory lectures on the nature-versus-nurture theme?

In this article, we argue that Gesell is very much a part of contemporary developmental study but that his influence is both subtle and largely unrecognized. To make our point, we critically evaluate Gesell's developmental theory and his contribution to the scientific study of the child, emphasizing the social and intellectual climate in which he worked. We speculate on why even before his death his direct influence waned, leaving few disciples. Finally, we show that there are strong neo-Gesellian themes recurrent in many streams of contemporary developmental study, and we suggest a reevaluation of the enduring nature of his influence. We begin with a brief summary of Gesell's career.

Arnold Gesell's Professional Career

Gesell's professional experience was uniquely rich and broad. He was trained as an educator, as a developmental psychologist, and as a physician at some of the foremost institutions of his day, and he practiced actively in these fields of child development throughout his career. In each professional capacity, he maintained his commitment to normative description and child welfare.

After receiving a teaching degree in 1899 from Teachers College at Columbia University, Gesell taught high school courses and then served as a high school principal. In 1915, he became the first official school psychologist for the State Board of Education of Connecticut, traveling from one rural school to another to identify handicapped students and organize special classes for them. From 1911 until 1948, Gesell served as director of the Yale Clinic of Child Development, where he maintained daily contact with teachers and children at the clinic's nursery school. The clinic recruited "well babies" and deviant children for normative observation and served the New Haven

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community by providing clinical interventions and advice to parents and adoption agencies.

Gesell and his fellow graduate student and friend Louis Terman received psychological training at Clark University under the tutelage of G. Stanley Hall. Both were trained in Hall's questionnaire method for describing "the contents of children's minds" (Kessen, 1965, p. 149), but Gesell especially admired Hall's commitment to Darwinian theory and his exuberant, wide-ranging inquiry into developmental process (Gesell, 1952a). Terman (1906) wrote a dissertation entitled *Genius and Stupidity*, whereas Gesell (1906) investigated normal and abnormal manifestations of jealousy in animals and humans at ascending age periods beginning with infancy. Both received doctoral degrees in 1906. The following year, Gesell joined Terman as professor of psychology at the Los Angeles State Normal School. Whereas Terman contributed to our knowledge of gifted children and the technical and statistical problems of intelligence testing, it was Gesell's use of developmental tests as a theoretical device that promulgated the traditions of Darwin, Galton, and Hall (Kessen, 1965).

In 1911, Gesell was appointed assistant professor of education at Yale, where he taught courses in the graduate school and began his medical studies. This third area of professional training was tackled to gain a "realistic familiarity with the physical basis and the physiological processes of life and growth" (Gesell, 1952a). In 1915, Gesell received his medical degree from Yale and was promoted to professor of child hygiene in the graduate school. In 1935, largely because of Gesell's influence, the American Board of Pediatrics established the field of growth and development as a basic requirement for specialty certification, formally acknowledging the importance of developmental principles for preventive medicine (Gesell, 1952a). Gesell continued his clinical practice as counseling psychologist-pediatrician even after his mandatory retirement from Yale in 1948.

From the early 1930s to the later 1940s, Gesell was at the height of his career. The Yale psychoclinic grew from one room with a table and desk into a world-renowned center for testing, clinical intervention, and graduate and medical training, occupying five floors of the Yale Human Relations Institute, with a staff of 31. Associates such as Halverson, Castner, Thompson, Washburn, Ames, Ilg, Amatruda, Bullis, and Learned amassed enormous amounts of normative data and published prodigiously with Gesell on a range of topics from infant development to adolescent development, both normal and deviant. The clinic's research program had a large endowment during these years, primarily from the Rockefeller Foundation, and impressive facilities for photographic and cinematic recordings were constructed. In the last 2 years before Gesell's retirement, more than 2,000 visitors came to the clinic to use the voluminous film library and learn Gesell's diagnostic techniques (Ames, 1989).

Shortly after Gesell's mandatory retirement in 1948, the Human Relations Institute was dismantled. The clinic survived with a grant from the American Optical Company, which allowed collection of normative data on the development of vision (Gesell, Ilg, & Bullis, 1949). In 1950, Yale University refused to continue to sponsor Gesell's clinic. Given the enormous success of the clinic, its worldwide reputation, and

Gesell's renown, Yale's actions seem nearly inexplicable. Louise Ames (personal communication, August 1991), attributes their removal to several factors, including the ascendancy of Freudians in the Department of Psychiatry, the dominance of learning theorists in experimental psychology, and the general distrust that academics feel toward colleagues who are widely popular and who write for general audiences. Nonetheless, with the swing of the intellectual pendulum to more biological psychology, Yale has had a change of heart and recently even established an Arnold L. Gesell professorship in the Yale Child Study Center.

After leaving Yale, several of Gesell's colleagues purchased a modest building that they renamed the Gesell Institute, at which normative and clinical research continued despite scarce funding. Daily newspaper columns in 65 papers throughout the country and a television program provided advice to parents and raised funds for the new clinic, which allowed the group to follow their remaining subjects through adolescence and culminated in their final major book, *Youth: The Years From 10 to 16* (Gesell, Ilg, & Ames, 1956), in 1956 (Ames, 1989). The Gesell Institute continues today.

Gesell's Theory

More than many theorists, Arnold Gesell maintained an internally coherent, steadfast, and clearly articulated theory of development throughout his nearly 40 years of active research and writing. To understand his unwavering commitment to his principles of growth despite the comings and goings of contemporaries such as Anna Freud, Watson, Piaget, Lewin, and Margaret Mead, it is useful to consider Gesell's own intellectual heritage, which he often explicitly acknowledged.

Like Piaget, Gesell claimed deep roots in the science of biology. Also like Piaget, he saw all behavior and mental activity as continuous with and inseparable from other biological processes, including those that engender the physical form of the organism. (Gesell differed from Piaget, however, in his account of the nature of those processes.) Gesell's vision was of a unitary science of development, encompassing evolution, comparative psychology, embryology, neurophysiology, and anthropology, and he continually wove these perspectives into his accounts of human infants and children (cf. Gesell, 1928, 1945, 1948). Two influences were particularly powerful: Charles Darwin, as the father of the scientific study of the child, and G. E. Coghill, who along with other early embryologists was the first to detail processes of behavioral growth experimentally.

Gesell's Darwinian Legacy

Gesell's debt to Darwin was twofold. First, Gesell venerated Darwin for rescuing human infants from the speculations of philosophy and theology and admitting them into the domain of respectable scientific inquiry. Before Darwin, infants and children were understood primarily in theological terms—as possessed by original sin or to be saved by baptism. According to Gesell (1948, p. 44), these "gloomier beliefs of fixity and fate" trammled the spirit and stifled any scientific inquiry into human nature. Because Darwin established the gradual origins of all living things, including the human mind, Gesell (1948, p.

44) credited Darwin with giving scientists "absolute freedom in the study of laws of nature. . . . Without that freedom it would be impossible to penetrate into the meaning of human infancy and into the nature of child development."

Just as Gesell paid tribute to Darwin's seminal role in the intellectual heritage of child study, he also greatly admired Darwin's methods of investigation. Gesell saw Darwin, perhaps as he saw himself, as a naturalist, "tirelessly" seeking "ideological order" (Gesell, 1948, p. 36). This order was gained through relentless observation and comparison. Gesell (1948, p. 37) remarked that Darwin "left no stone unturned in his search for data." For example, in his investigations on the origins of human emotions, Darwin closely observed his own children and studied emotional expressions in other animals and in children and adults of other cultures. He was interested in the physiology of emotions as well. According to Gesell (1948, p. 43) contemporary child development study also needed "the naturalist's breadth of vision." Gesell (1948, p. 57) followed Darwin in thinking that "the understanding of the human mind . . . will be attained not through the researches of a single discipline, but through the conjunctive results of a great interlocking system of sciences."

This discussion of Gesell and Darwin raises a recurrent tension, which is the central enigma of Gesell's legacy: the resolution of Gesell's clearly articulated beliefs in ultimate biological causality with his equally firmly held ideals of human freedom. Gesell clearly owes to Darwin his core assumption that the growth of mental life is continuous with and impelled by the same processes that drive all organic growth. The assumption that the forces of natural selection work with equal power over all aspects of function led Gesell from descriptions of the orderly progression of motor development in infancy to equally detailed and orderly accounts of intellectual, personality, and social stages during all of childhood and adolescence. Once he demonstrated order in development, however, Gesell ascribed this order to biological destiny. Critics might detect a certain irony in Gesell replacing the fixity and fate of the Calvinist view of childhood with a biological determinism that is in many ways as rigid. We see variations of this paradox repeated in all aspects of Gesell's work and career. How does Gesell reconcile a genetically driven maturational program with his beliefs in children's individuality and active exploration of the environment, importance of the nursery, preschool and school environment, and his concern for child welfare both in the home and in society at large? How can he be so aware of the dynamic interplay of multiple influences in development and yet ignore these processes in favor of biological causation? Gesell's decline as a major developmental theorist is due at least in part to these unresolved tensions in his work.

Coghill and the Influence of Embryology

Gesell's contemporary, embryologist G. E. Coghill (1969), stood second only to Darwin as an inspiration to Gesell. (Myrtle McGraw, e.g., 1935, also drew heavily on Coghill for her maturationist-organismic approach to development.) Gesell believed that Coghill, in his studies of the embryo of the salamander *Amblystoma*, had unearthed the very essence of vertebrate development, and Gesell used Coghill's work as an ex-

PLICIT model for his research on human infants. According to Gesell (1946, p. 295), in the hands of Coghill, "this primitive vertebrate . . . has become a touchstone for elucidating problems of human behavior."

Coghill's major contribution was to show a correlation between behavioral development and corresponding changes in the nervous system. In the work that so captivated Gesell, Coghill first described the ontogeny of locomotion in *Amblystoma* in exquisite detail and then traced the neurological and muscular basis of those movements. Most exciting to Gesell was Coghill's demonstration that the onset of particular behavioral configurations was coincident with the growth of specific neural connections. Because Coghill found that these early motor patterns emerged before the animal developed the corresponding sensory tracts, he concluded that swimming was the result of these neural connections and not their cause.

Coghill's Enduring Legacies

A number of Coghill's legacies dominate Gesell's work. First is the idea that behavior has form and that development can be understood by changes in shape or morphology of the organism's behavior. It is instructive to compare Coghill's tracings from motion pictures of the swimming patterns of *Amblystoma*, for instance, with Gesell's films of the postures and movements of infants. It was surely this preoccupation with documenting changing form that compelled Gesell's monumental labors in photographing infants and children in all aspects of their lives. Indeed, throughout his career Gesell was to claim that "posture is behavior. Postural patterns are behavioral patterns" (Gesell & Thompson, 1934; see also Gesell, 1952b, p. 65). Only within the last few years, with the rediscovery of Bernstein (1967) and renewed interest in motor development, would this statement be viewed with any seriousness. Where Gesell may have gone beyond Coghill, however, was in his extension of the principles of morphology and growth to all facets of mental life. This led Gesell to a descriptive classification of children's expected behavior almost absurd in its detailed caricatures of age-related changes (cf. Gesell & Ilg, 1943).

Second, Gesell derived from Coghill that behavioral morphology is a direct readout of the neural structures that underlie it. "How does the mind grow?" asks Gesell. He answers, "It grows like the nervous system; it grows with the nervous system. Growth is a patterning process. It produces patterned changes in the nerve cells; it produces corresponding changes in patterns of behavior" (Gesell & Ilg, 1943, p. 18). Gesell repeats this principle continually, and it stands as the justification for his dominant enterprise: developmental norms. That is, the behavior of the child in relation to his or her expected maturational stage reflects the integrity of the nervous system. This is perhaps Gesell's most enduring legacy, as we discuss further.

Third, and perhaps most important theoretically, is that these neural changes are autonomous products of growth, inherent and lawful, and not subject to the influence of function. "Patterns of behavior in all species tend to follow an orderly genetic sequence in their emergence," Gesell wrote. "This genetic sequence is itself an expression of elaborate pattern—a pattern whose basic outline is the product of evolution and is under the influence of maturational factors" (Gesell, 1933, p.

217). Throughout his career, Gesell remained unwavering in his conviction that maturation was the ontogenetic source of all behavior. He was abundantly aware of the questions raised about his view. What and how do children learn? What is the role of the environment? How does one account for individual differences? Gesell addressed these questions frankly if not entirely consistently within his theoretical view.

For example, Gesell's descriptions of the experiential world of the infant would do justice to Piaget or E. J. Gibson and is consistent with contemporary neuroembryological theories of the origins of mind (e.g., Edelman, 1987). On the acquisition of the infant's sense of self, Gesell and Ilg (1943, p. 33) wrote:

He spends many moments looking at his hands, fingering his hands, mouthing his hands. These sensory experiences,—visual, tactile, wet, dry, still, moving, stop-go, oral, palmar, touching and being touched, provide him with a medley of data. By gradual degrees he comes to realize that he has a hand which feels when it contacts (active touch), which feels when it is contacted (passive touch), which feels when it is moved (sense of motion, or kinaesthetic sense mediated by sensory end organs in muscles, joints and tendons). His ceaseless manipulation, therefore, acquaints him not only with the physical universe and the physical presence of other persons, but with the physical presence of himself. . . . His manipulation of objects also gives him an increasing sense of mastery of his environment.

Gesell (1933, p. 214) noted that even the salamander's behavior was not fixed and rigid, so experience must have "much to do in determining when and to what extent performance will take place." How then can patterns of behavior, their timing as well as their form, be ultimately configured by the genes? Again, Gesell referred to Coghill: The neural structures for the mechanisms of learning must also mature, like the motor mechanisms, to anticipate their function.

Gesell and the Growth of Individuality

The domination of structure is the genesis of Gesell's beliefs about individual differences, which posed a formidable challenge to his views and which he met with less than full success. Gesell devotes chapters (e.g., Gesell, 1928; Gesell & Ilg, 1943) and indeed entire books (Gesell, Amatruda, Castner, & Thompson, 1939) extolling infants as individuals and describing the individuality of their growth patterns in relation to his developmental norms in short vignettes. Where does this individuality come from? In his earlier works, Gesell seemed puzzled and ambivalent. In describing children who on developmental tests "frequently" have equivalent scores but "differ chronologically by two, three, five, or ten years," he wistfully wrote, "Their very equivalence emphasizes their contrasts and calls for an interpretation of these contrasts in terms of habituation, inheritance, environment" (Gesell, 1925, p. 291). What to make of these "developmental peers of incongruent age" (Gesell, 1925, p. 291)? Gesell viewed both retardation and precocity as potentially unbalancing the harmonious progression of normal development, especially when parents or others induced children to perform beyond their naturally unfolding patterns of growth.

In his later works, Gesell was more direct and explicit in explaining behavioral individuality. Infants are individuals from before birth, and their individuality manifests itself not

only in characteristic pathways of physical growth but also in stable and enduring personality traits and in the maturation of mental styles and capabilities. Individual differences in behavior are as much a part of the organism as patterns of physical growth, and all are traits inherited both from the family and from the race as a whole. Although infants are plastic and learn from the culture, the limits of this plasticity are themselves genetically determined. Children's constitutions determine "how, what, and to some extent even when" they will learn (Gesell & Ilg, 1946, p. 40).

Gesell viewed individuality in another important way. At the same time children have innate and prefigured individual developmental pathways, they also have biological individuality as a function of their age. This individuality is reflected in physical skills, cognitive abilities, and temperament. Only Gesell's own language can convey the strength of the stage imperative (Gesell & Ilg, 1943, p. 224):

THREE has a conforming mind. FOUR has a lively mind. THREE is assentive; FOUR, assertive. Indeed, FOUR tends to go out of bounds both with muscle and mind. And why should he not? If he remained a delightful, docile THREE, he would not grow up. So he surges ahead with bursts of movement and of imagination. His activity curve again takes on the hither and thither pattern typical of TWO YEARS. . . . If at times he seems somewhat voluble, dogmatic, boastful and bossy, it is because he is a blithe amateur swinging into fresh fields of self expression.

Poetic language aside, there is a sense throughout Gesell's voluminous descriptions of the lives of children from newborn through adolescence of a relentless inevitability, of an organism neither in control of itself nor impelled by forces surrounding it. Rather, the child seems possessed by a resident homunculus, capricious but wise, whose wild mood swings serve in the end the developmental dialectic. Gesell never resolves these dual aspects of individuality: how a child maintains individuality, whatever its source, while at the same time marching through an inexorable series of prescribed stages.

Given his views on individual differences, what did Gesell see as the importance of the family, the school, and the culture? In both his writing and his clinical and policy work, Gesell was clear. Society and the family must provide children with an environment that allows the inherent growth potential of each child to be fully and optimally realized. The whole purpose of developmental norms was to identify the individual status of each child so as to guide children more suitably to optimal growth. The environment must be precisely tailored to fit the child's capabilities. Children who are delayed must be provided with a supportive and humane environment; those who are accelerated must be watched for balanced growth. No child should be given tasks beyond his or her state of maturational readiness. In a guidance nursery, the guidance teacher must continually channel the natural tendencies of the children into constructive and appropriate activities.

Thus, Gesell's enterprise for the scientific study of the child led him from the naturalist's belief in description and categorization to the physiologist's need for understanding mechanism to the physician's consideration for diagnosis and diagnostic categories and ultimately to the educator's concern for the welfare of children. As we will discuss, Gesell had many blind spots, and his theory is by any account both incomplete and

stifling. He also had many brilliant insights, he was motivated by a lifelong devotion to the well-being of children, and he remains a pervasive if not fully acknowledged influence on the field.

Embryology and the Process of Development

Before leaving the topic of Coghill and his legacy, it is important to mention another common thread, one that we see as a continuing influence on contemporary developmentalists. Coghill was well known for his principle of behavior differentiation: that mature behavior evolves through a process of increasing specificity from an integrated substrate rather than being constructed from isolated reflexes. The developing organism is a gestalt, not a collection of incomplete pieces; specific functions are carved out and not glued together. Coghill and Gesell after him saw no distinction between the processes of differentiation and growth of the earliest embryo and those of later neurological and behavioral development and indeed, for Gesell, all aspects of mental activity.

Gesell's embryology was most directly reflected in his *principles of behavior development*, which he articulated in his later works (Gesell, 1946, 1952b). The *principle of developmental direction*—that behavior proceeded from head to toe and from proximal to distal structures—echoed the embryological concept of polarity and gradients. His dialectic *principle of reciprocal interweaving* reflects the cyclic ebb and flow of organic life, the essential excitation and inhibition or “duplexity . . . reflected in life processes at every level of functioning” (Gesell, 1952b, p. 67). Not only is reciprocal interweaving characteristic of the changing dominance of flexor and extensor muscles in infancy but also of the development of the senses and the emotions. Reciprocal interweaving does not produce complete symmetry, however, as “nature evidently did not intend” (Gesell, 1952b, p. 67) humans to be completely balanced. According to the *principle of functional asymmetry*, the infant must break free from symmetry to accomplish functional ends such as lateral handedness, much as even the organ systems in the embryo cannot be perfectly symmetrical. Embryological themes are again dominant in Gesell's *principle of self-regulation*. As all organisms store and distribute energy, “the maturing organism oscillates between self-limiting poles as it advances” (Gesell, 1952b, p. 68). But the thrusts and retreats of the developmental process must be kept within bounds. This inherent self-regulation also protects the developing organism from too many or irrelevant or dangerous stimuli. Likewise, organic integrity is preserved through the *principle of optimal realization*, which buffers the organism and maintains its integrity even when resources for growth are threatened.

The embryological themes became closely woven with a distinct systems approach by the mid- to late 1940s. At that point, Gesell was citing von Bertalanffy (Gesell, 1946), and it is likely that the developmental principles reflect this influence. As we elaborate further, Gesell's systems principles are incorporated in many aspects of contemporary dynamic systems theory in development.

The Coghill assumptions were critical to every aspect of Gesell's theory. They guided nearly a half century of descriptive

research. We continue our evaluation of Gesell's impact by discussing his research.

Gesell's Contribution to the Scientific Study of the Child

Most of the research conducted at the Yale psychoclinic was devoted to compiling a comprehensive schedule of developmental norms. These norms were presented in nearly every published work either quantitatively in percentages and averages or qualitatively in the form of developmental vignettes or age caricatures. Postural, prehensory, adaptive, social, and linguistic abilities were observed from infancy (including preterm “fetal infants”) to adolescence at specified intervals. Some children were observed cross-sectionally and others longitudinally at either monthly or yearly intervals. More than 500 children, 50 at each of 10 age levels, contributed to the original developmental norms (Gesell & Thompson, 1934). Interestingly, children were carefully sampled from the New Haven community to provide a homogeneous, white, middle-class group of British or German extraction from intact two-parent families (e.g., Gesell & Thompson, 1938). This sample, however, was meant to generalize to any infant, regardless of upbringing, environmental opportunities, and racial heritage, and was presented to clinicians as the yardstick from which to diagnose abnormality in development (see especially Gesell et al., 1939; Gesell & Amatruda, 1941).

In particular, Gesell and colleagues concentrated on documenting age-related change in behavior patterns during children's first year of life. Observations were scheduled at monthly rather than yearly intervals during this period, and more data were collected at each testing session. For these first months of the infant's life, Gesell looked for preformations of later behavior patterns. In fact, the battery of test items and behavioral situations were organized according to the assumption that mature forms of a behavior (e.g., “plucks pellet with precise pincer prehension”) are presaged in early forms (in this case, “visual prehension” at 4 weeks prefigures pincer grasp at 40 weeks). At each stage, Gesell described involvement of the total organism and the holistic behavioral pattern rather than its piecemeal construction. Today, protobehaviors are well-accepted concepts, as witnessed in Trevarthen's (1977) protocommunication or von Hofsten's (1984) prereaching, or Meltzoff and Moore's (1983) neonatal imitation.

Adequate procedures for collecting normative data in infancy required a keen appreciation for these small and taciturn subjects. After the flurry of motor development research by Gesell and his contemporaries such as Mary Shirley and Myrtle McGraw, developmental psychologists and pediatricians nearly uniformly emphasized young infants' reflexive behavior or their incompetence in relation to older children and adults. From the beginning, Gesell focused on young infants' perceptual-motor and social competence and their ability to purposefully exploit aspects of the environment rather than focusing on their inadequacies.

Procedural and Methodological Innovations

Gesell's behavioral interview, the centerpiece of his normative research, was exceedingly clever. Simple materials such as

an enamel cup, a small bell, a red wooden block, or a sugar pellet were presented straightforwardly to the infant in the hope that these homely objects "carried their own enticement" and that "the infant has an ingrained propensity to exploit his physical environment" (Gesell & Thompson, 1934, p. 35). Most test materials were presented repeatedly to children at different ages on the assumption that infants would attend to the stimulus values appropriate to their developmental level. For example, infants first used the performance box, a 20-cm × 20-cm × 40-cm construction with slots for the insertion of various rods and shapes to pull themselves to the erect position. Weeks later, the box was used primarily for its intended purpose, inserting rods into the holes (see Gesell & Thompson, 1934, p. 34). Years before E. J. Gibson and colleagues began investigating infants' exploration of the affordances of objects and events, with the belief that shifts in attention to environmental properties are driven by development of new action systems (e.g., E. J. Gibson, 1988), Gesell and Thompson (1934, p. 293) wrote that "development is a process in which the mutual fitness of organism and environment is brought to progressive realization. This process . . . is a series of biochemical, morphogenetic events: a process of continuous differentiation, 'coordinated in time and place, leading to specific ends'."

The behavioral interview was designed to promote active responses that reflect infants' competencies, even during the first month of life when the behavioral repertoire is limited. Long before young infants' active looking, listening, mouthing, and manipulative behaviors were exploited experimentally in preferential looking or habituation tasks (e.g., Cohen, 1972; Fantz, 1958), long before infants' spontaneous arm, leg, or head movements were harnessed for contingent reinforcement paradigms by American psychologists (Rovee & Rovee, 1969; Siqueland & Lipsitt, 1966), and long before the era of "the competent infant" (e.g., Stone, Smith, & Murphy, 1973), Gesell had used infants' manifold abilities to formulate his developmental norms.

The apparatus used to conduct the behavioral interviews were equally innovative and clever in a homespun and simple way. Gesell expends many pages describing in words and photographs the specially built multiuse crib (which transformed from sleeper to test table to playpen to fort), the many-pocketed materials bag, the support chair (adjustable for different levels of postural control, with washable canvas inserts), the examination playhouse in the nursery room (with gabled roof, built-in "reaction screens," and "secret" basement passage to entice reluctant preschoolers to enter), and so on (e.g., Gesell, 1928; Gesell & Thompson, 1938). Perhaps drawing on his background as a teacher or his clinical experience with young children, Gesell considered each aspect of his testing procedure in minute detail. Explanations are given of how to make friends with babies, precautions against frightening them, and exhortations to gain mothers' trust before the interview (e.g., see Gesell & Thompson, 1938, pp. 65–68). In fact, the infant is often discussed in the context of the mother–infant dyad, prefiguring many modern research topics (e.g., Gesell, 1928).

In addition to the behavioral interview, Gesell compiled normative data on the infant's behavioral day primarily from parental reports but also collected in the institute's research "hotel," in which mother and infant spent a few days under continuous observation (Gesell, 1928; Gesell & Ilg, 1937; Gesell & Thomp-

son, 1938). These data were used to justify more relaxed feeding and sleeping schedules than advised by Gesell's predecessor, J. B. Watson (1928), who had prescribed rigid schedules and minimal physical contact with young infants. The comparative behavioral interview examined two babies of different chronological ages simultaneously in the same task, mostly for demonstration purposes. The experimental method of co-twin control (appropriate only for identical twins) was used to test the effects of specific training versus maturation on development (e.g., Gesell & Thompson, 1929). As in McGraw's (1935) classic study of Jimmy and Johnny, Gesell gave one twin several weeks of training in a task such as stair climbing and then compared behavioral patterns with those of the control twin tested at the same chronological age before and after the training regimen. These studies provided further support to the maturationist perspective because the control twin usually achieved a similar developmental level without special training.

Action Photography and Cinematography

From his earliest writings, Gesell was fascinated by the research opportunities afforded by photographic technology. He saw the camera's eye as impartial, precise, and permanent. A generous endowment from the Laura Spelman Rockefeller Foundation in 1926 provided funding for the construction of elaborate photographic recording studios, apparatus for developing and analyzing film, and a voluminous archival film library.

Every aspect of the cinematic procedure from recording to analysis was designed and described in minute detail (e.g., Gesell, 1928): appropriate ambient lighting, innovative one-way vision screens, the famous photographic dome (Figure 1), film development, coding procedures, and "cinemanalyses." Several major publications were devoted solely to presentation of action photography and cinematic data (e.g., Gesell, Thompson, & Amatruda, 1934), and numerous films were edited for educational and public viewing.

In his many publications, Gesell rarely mentioned the early work of Muybridge and never credited the innovative film techniques of his own contemporary, Myrtle McGraw. Ironically, the vast film library so carefully catalogued and compiled from more than 20 years of cinematic recordings was abandoned after Gesell's clinic was separated from Yale University. Many films were lost because of poor storage facilities, and the remaining recordings are currently housed at the University of Akron.

What is the lasting legacy of Gesell's methodological and technical innovations? The photographic records presented throughout Gesell's books are astonishingly clear and elucidating. Gesell's verbal pictures of infants and children are less illuminating, however, often cartoonlike caricatures of behavior. Compared with his contemporaries, Piaget, Shirley, or McGraw, Gesell's verbal descriptions have less import, and they are rarely cited today.

From Description to Prescription

The thrust of Gesell's empirical legacy was a catalogue of infant and child behavior. Like the naturalists whom he ad-



Figure 1. Gesell's photographic dome. (From *Infancy and Human Growth* by A. Gesell, 1928, p. 67, Fig. 25, New York: Macmillan. Copyright 1928 by Macmillan. Reprinted by permission.)

mired, he described to classify. From the range of variability he saw—however truncated his sampling and selective his vision—he distilled the essence of both what the child was like and what the child was doing. The typical 1-year-old spends a typical day: eating, sleeping, eliminating, and being social in neat progression (Gesell & Ilg, 1943). Just as biological species have morphology and exist in time and place, so does the behavior of the child, and the latter can be classified and labeled just as confidently as the skulls and skins of the natural history collection. Indeed, Gesell claimed that the ossification of the wrist bones was more variable than normal infant behavior (Gesell, 1928).

The sleight-of-hand here was Gesell's leap from description—what is—to prescription—what ought to be—and thus his lifelong preoccupation with developmental norms. Developmental norms for infants and children were a direct heritage from Gesell's association with Terman as well as the influence of Galton, Hall, and Binet. Like Binet, Gesell was motivated by his concern for providing education that was appropriate for the child's capabilities and for diagnosing delayed development for the purposes of intervention. But somehow within these laudable clinical goals, there was a transformation from the typical into the desirable. Gesell elevated the typical child, who of course was no child, into a biological reality with profound consequences for both theory and practice.

The Legacy of Developmental Norms

Norms of development are without question Arnold Gesell's most enduring legacy. Many items in his test battery have been imported virtually unchanged into the two most widely used infant developmental tests: the Denver Developmental Screening Test and the Bayley Scales of Infant Development. According to Louise Bates Ames, Gesell's long-time associate and the

director of the Gesell Institute after his death, the so-called Denver developmental test is a "flagrant unacknowledged use of Gesell test items," with only the substitution of raisins for pellets (Ames, 1989, p. 116). These tests are widely accepted and frequently used all over the world for both research and clinical purposes. The vast bulk of scholarly citations to Gesell over the last 25 years have been to his developmental norms (Table 1), referenced in an astounding range of fields, including developmental psychology, education, medical and clinical sciences of every type, anthropology, and other social sciences. Nearly every developmental textbook contains the obligatory inclusion of a table of motor milestones in the infancy chapter. Indeed, it is probably hard to overestimate how thoroughly we have internalized the idea of age-appropriate activities as an index of intrinsic biological functioning.

In addition to the patent and undeniable value of developmental norms for diagnosis, other aspects of the heritage were more subtle and perhaps less clearly beneficial. First was the elevation of empirical data into statements of eternal values. Parents reading Gesell's popular books such as *Infant and Child in the Culture of Today* (Gesell & Ilg, 1943) saw descriptions of "typical" infants and children drawn in such detail and with such confidence that even minor deviations might be viewed with alarm. And because the typical child was a quasistatistical amalgam, every parent's child would naturally deviate.

Gesell's motives for developing norms were to promote the "mental hygiene" of the child, and he meant them to inform and reassure parents and teachers. "We must not lose faith if at the age of $2\frac{1}{2}$ years the child grabs a toy from his playmate; if at 4 years he calls names and brags and boasts and tells tall tales . . . we must recognize the nature of his immaturity" (Gesell, 1948, p. 9). Nonetheless, as Kessen (1965, p. 210) later wrote, "the detail and volume of his descriptive works (together with the avid reception given his books by mothers keen on quantify-

Table 1
Gesell's Most Cited Publications

Publication	Years of citations ^a					Total citations	Mean citations per year	SD
	1966–1970	1971–1975	1976–1980	1981–1985	1986–1990			
Developmental diagnosis (1941)	86	80	111	71	55	403	16.12	6.42
First 5 years of life (1940)	46	61	58	57	38	260	10.40	4.16
Child from 5 to 10 (1946)	29	30	31	27	10	127	5.08	2.93
Journal of Genetic Psychology (1947)	9	10	41	37	23	120	4.80	3.50
Embryology of behavior (1945)	24	13	28	22	7	94	3.76	2.24
Infant and child in culture today (1943)	17	13	25	17	9	81	3.24	2.11
Youth: Years 10 to 16 (1956)	12	18	26	11	8	75	3.00	2.02
Vision: Its development (1949)	25	15	15	7	5	67	2.68	1.95
Infant behavior (1934)	6	10	25	15	9	65	2.60	2.00
Manual child psychology (1946)	16	8	11	12	7	54	2.16	1.37

^a Data taken from Social Science Citation Index, 1966 to 1990.

ing the hitherto imprecise business of comparing babies) block an appreciation of his intentions.”

The typical child living his typical day was clearly male, white, native-born, middle-class, and in an intact family, with a virtually invisible father and a devoted but strangely passive mother who acted without agency in an intermittently compliant culture. An extended quotation (Gesell & Ilg, 1943, p. 135) conveys the subtle force of the language. At 15 months old, for example:

At about 12:30 he is toiletied and may have his first or second bowel movement, after which he is returned to his crib. The effects of acculturation now become evident. Typically he makes no protest against the impending nap. He snuggles under his covers. He likes to watch the shades go down. . . . He is likely to wake wet. He is changed and toiletied. He usually wakes in high mettle, eager to get out of his crib to continue with his behavior day. . . . Having arrived in the park or in a neighbor's play yard, he likes to be set free on the wide expanse of a lawn or a sidewalk. . . . He returns home at about 4:30 and continues his characteristic play activities, utilizing the apparatus of the living room, with a special interest in all containers, particularly waste-baskets.

Did Gesell and his typical child really influence how a generation of parents raised their children? Were parents beset with worry and guilt if their child wasn't completely toilet trained by 2 or did not manifest interest in containers at 15 months? We cannot answer these questions in this essay, but we do know that many thousands read Gesell and took him seriously. Especially in social classes and cultures in which the mechanics of child-rearing were not universally learned through the extended family and in which experts and scientific advice permeated even the economics of the home, Gesell clearly filled a need. Is my child all right? Am I raising him or her correctly? The paradox of Gesell's answer remains: Yes, your child is an individual, but let me tell you what he or she should be like. Yes, a nurturing environment is important, but gender, class, race, ethnicity, geography, personal values, and style were subservient to the biological imperative embodied in the behavioral norms. At the same time, that very biological imperative could give parents a sense of enormous relief. Parenting might not engender later neuroses or more severe emotional illnesses, as a generation raised with Freud and his followers might believe. (Recall that as late as 1967, Bettelheim [1967] was blaming childhood

autism on mothers' emotional coldness.) Nor could parents, by their scheduling or conditioning routines, infinitely mold their children's personalities, as suggested by other Gesell contemporaries. Gesell therefore delivered a double message, one that could be both reassuring and alarming.

The second, more subtle, and more lasting legacy of Gesell for the profession was the elevation of developmental stages not only into desirable way stations on the way to middle-class maturity but into real neurological structures generated by genetic design. So inexorable was the unfolding of the ontogenetic pattern from the embryo to the adult that stages became reified, with age the only explanatory variable. In an early account of his normative sample, in which he admitted to leaving out the very bright, the very dull, the very poor and children from homes where languages other than English were spoken, Gesell reassured readers that they examined children only within two weeks of their chronological age: “Whatever imperfections our method of selection may have in other directions, with respect to this factor of central importance it is reliable” (Gesell, 1925, p. 42).

Gesell and the Behaviorists

Gesell's tenacious biological determinism seems all the more remarkable considering that his work precisely paralleled that of the great learning theorists: Tolman, Hull, Skinner, and especially John B. Watson. It is crucial to note here that Gesell was not writing in ignorance of learning theory but in direct and conscious opposition to it. “The extreme versions of environmentalism and conditioning theories,” wrote Gesell (1933, p. 230), “suffer because they explain too much.” Most contemporary developmentalists would agree. He continues:

They suggest that the individual is fabricated out of the conditioning patterns. They do not give due recognition to the inner checks which set metes and bounds to the area of conditioning and which happily prevent abnormal and grotesque consequences which themselves would make too easily possible.

Although environment channels and modifies development, it cannot generate growth. It lacks the structure to produce the regularity of outcome Gesell documented. The inherent and destined individuality of children protected them from ran-

dom and perhaps evil influences of the physical, social, and political milieu. Writing in an age that saw the rise of racial hatred, genocide, war, and mass manipulation of never-imagined proportions, Gesell retained a steadfast belief in the ultimate outcome of optimal growth. The role of the scientist in bettering human nature, Gesell believed, was not to manipulate and predict human behavior, but to watch it, understand it, and optimize its natural self-righting course. By taking care of our children, we would set the world right (Gesell, 1948).

Again, we come up against the central paradox of Gesell. He was impelled throughout his career by a deep and abiding concern for providing nurturant family and school environments. He witnessed the turbulence of two world wars and the rise of Nazism and the nuclear age. He recognized the unity of child and environment. Yet neither in his theory nor in his research was he explicitly concerned with the mechanisms that integrated growth with the environment that sustained and guided it.

Gesell and Contemporary Developmental Psychology

Gesell's legacy, like his career, is dualistic and somewhat paradoxical. On the one hand, Gesell's developmental norms continue to be a visible and lasting influence. On the other hand, his theoretical contribution is pervasive but less direct. In distinct contrast to Piaget, Gesell left no army of disciples in virtually every psychology and education program in the Western world. He did not spawn tens of thousands of studies to expand, support, or contradict his research. He inspired few revisionists or neo-Gesellian defenders. No annual conferences are held in his name.

It is not difficult, given Gesell and his times, to speculate why this is so. First and foremost, Gesellian developmental psychology leaves experimental psychologists with nothing to do. The child unfolds; understanding is through observation. The only formal experiments Gesell did were his studies with twins, which were hardly models of experimental science. Gesell thought it worthwhile to use genetics as the independent variable, but because the environment did not engender differences or change, in his system experimentally manipulating the environment would not test basic developmental processes. Thus, there was nothing in Gesell to generate the rigorous hypothesis testing to which the science of behavior aspired. At the same time, Gesell was not modest in proclaiming that he and his colleagues preempted the field of observation and description. For example, Gesell never mentions or cites his contemporary Myrtle McGraw, whose documentation of early motor development was equal and in many ways superior to Gesell's in technical and descriptive elegance. One would not know from reading Gesell that other large longitudinal growth studies were being conducted in Iowa, Berkeley, or Yellow Springs. In short, the theory squelched experimentation while leaving the impression that the necessary observational studies were conducted in Gesell's laboratory alone.

Second, Gesell fell from grace because his theory simply was insufficiently mentalistic to accommodate the domains of mainstream psychology. Gesell was disinterested in the content and workings of the mind. He thought of Piaget, for example, as "too mentalistic to be readily brought into a biological discus-

sion" (Gesell, 1933, p. 226). Gesell's theory was just as "black box" as the most strict stimulus-response psychology, but he substituted biological destiny for the equally unspecified mechanisms of association. Gesell was additionally unpalatable, however, because he was nonexperimental. So in a climate dominated by learning theory but also seeing the rising influence of Piaget and a growing interest in memory and cognition and in information-processing metaphors, Gesell must have appeared to be a musty cataloguer in the same way that natural history curators would be viewed by modern molecular biologists—interesting, perhaps, but irrelevant.

The most fundamental reason that Gesell has not inspired succeeding generations is that his theory is itself incomplete, deterministic, and leaves little room for the study of developmental process. Here Gesell might argue that growth is a process; we have discovered lawful principles and showed that they apply for many species and over many domains of change. Gesell's great logical error here was to assume that lawfulness and pattern can have its genesis only in lower level laws and prescriptions, that is, the genes. Gesell understood as well as any the dynamics of development: the totality of the organism, the cyclic phases of equilibrium and disequilibrium, the participation of infants in their own change, the self-righting tendencies of the organism. Yet he doggedly assigned the intricacies of development to a single cause. By explaining everything, he, like the behaviorists he criticized, explained nothing.

The most tangible legacy of Gesell was the virtual disappearance of the study of early motor development from the mainstream of developmental psychology from the mid-1950s until the last decade. Perhaps because of the growing mentalistic bias of psychology as a whole, developmentalists were content to relegate motor development to biology, and Gesell's accounts were accepted without criticism. Stages of motor development were and still are used as examples of a pure maturational timetable. Because these stages had been described fully by Gesell and his contemporaries, motor development warranted little further study. One turning point may have been Philip Zelazo's experiment that demonstrated a training effect on an infant reflex (P. R. Zelazo, N. A. Zelazo, & Kolb, 1972). So ingrained was the belief that although mental structures evolve through interaction, motor patterns represented the march of the genes, that this experiment captured wide attention. Only in the last decade, however, are process accounts of infant motor development supplanting the legacy of Gesell, and as we argue, maturationist assumptions still prevail in much contemporary developmental thinking.

Gesell as a Stage Theorist

Although the heritage of Gesell's developmental norms is clear, direct, and easy to document, his influence as a stage theorist is less obvious. Gesell raised stage theory to an unparalleled degree of refinement. Who before or since has had the tenacity to describe 58 stages of pellet behavior, 53 stages of rattle behavior, and so on for 40 different behavioral series (Gesell & Thompson, 1938)? Although such fine-grained descriptions of stages are absent in contemporary studies, it is likely that Gesell had a hand in the widespread acceptance of the stage theory of Piaget and his followers. Recall that Piaget, like

Gesell, viewed stages as biological necessities, part of the very architecture of growth, with its destined directionality and dialectic cycles of change. Today, there is ongoing debate over whether developmental stages represent neurological realities or convenient categories of the developmental theorist (cf. Brainerd, 1978). Nonetheless, stage theory continues to be a dominant theme, especially in the study of cognition. There are strong maturationist currents in contemporary stage theory as well. For example, in Case's (1985) neo-Piagetian approach, the overarching horizontal structures that determine children's functioning at any particular age are ultimately determined by working memory, a maturational function. Mounoud (1986) is more explicitly Gesellian. In describing the origin of developmental stages common to all areas of knowledge, he (Mounoud, 1986, p. 55) claimed,

This conception ascribes a more important role to the process of neural maturation and the biological substrates of behavior which determine the origin of steps in this developmental sequence. The maturation of the neural system itself depends on the nature of the interactions of the organism with the environment, but in a non-specific way these interactions at the most being able to accelerate or slow down the process.

Even removed from a Piagetian framework, there is widespread acceptance of maturationally based reorganizations of the brain occurring at regular intervals during infancy, for example, 2 months (Prechtl, 1982), 6 months (Diamond, 1990c; Mounoud, 1986), and 8–12 months (Diamond, 1990b; Goldman-Rakic, 1987; P. R. Zelazo, 1982).

Maturationist Themes in Contemporary Developmental Psychology

The search for behavioral change in neural maturation is a direct Coghill–Gesell legacy that continues with great vigor in contemporary developmental study (e.g., Diamond, 1990a; Gibson & Peterson, 1991). A number of structural changes have been hypothesized to account for performance changes. Some authors attribute the direction and pace of early development to rates and cycles of myelination (K. R. Gibson, 1991; Konner, 1991). Goldman-Rakic (1987) proposed that the explosion of cognitive skills seen in human infants from 8 months to 2 years of age could be attributed to the exuberant growth of cortical synapses during that period, which are later pared down, and Fisher (1987) has tried to relate cycles of synaptogenesis to sensorimotor levels in infancy. According to the extensive work of Diamond (1990c), the maturation of the hippocampus is necessary for recognition memory, and the prefrontal cortex is essential for tasks that require representational memory and the inhibition of predominant response tendencies (Diamond, 1990b).

A full understanding of behavioral development must include knowledge of its underlying neural structures and functions. Nonetheless, note that themes in the current work can lead to the same ultimate nativism as did Gesell's. If behavior emerges as the brain matures, what causes the brain to mature? The answer—if the question is addressed, which it frequently is not—is that the form and sequence of brain development and its behavioral manifestations are genetically encoded. In a recent article, Konner (1991, p. 199), explicitly citing Gesell, concluded, “motor development sequences are largely genetically

programmed.” Despite some cultural variability, consistency of motor milestones among populations “suggests a species-specific and species-wide timing of events in motor and sensorimotor development” (Konner, 1991, p. 200), presumably paced by myelin deposition.

Just as Gesell assumed that his stages reified the race's biological destiny, accounts such as Konner's assign the global similarity of developmental pathways to an executive agent; in other words, to a prescription in the genes for, say, the pattern of prehension, the timetable of the onset of locomotion, the inevitable stages toward acquiring Piagetian conservation, or the mechanism of parent–infant attachment. Although few today would assign the environment as little power as Gesell did, many believe in autonomous maturation, with structures whose final form is known by the genes and where time is meted out by a genetic clock.

Another common Gesellian theme in contemporary developmental studies is that of innate knowledge. “The human mind has an appreciable amount of innately specified knowledge about persons, objects, space, cause–effect relations, number, language, and so forth,” concluded Karmiloff-Smith (1991, p. 174). Innate knowledge means that the core knowledge structures of specific domains are genetically wired into the brain, as are the constraints on subsequent learning (e.g., Carey & Gelman, 1991). The infant is rational from birth (Bower, 1989). Evidence for innate knowledge structures comes from several directions. Surprisingly young infants appear to understand some properties of physical objects and their actions (e.g., Bailargeon, 1987; Spelke, 1988). Numerous experiments have demonstrated early perceptual biases for voices, faces, shapes, and other features that have been interpreted as innately adaptive (e.g., Alegria & Noirot, 1978; Fantz, 1963; Slater, Morrison, & Rose, 1983). In addition, many theorists believe that complex abilities such as language could not be acquired so rapidly without help from the genes in the form of built-in linguistically relevant principles (e.g., Pinker & Bloom, 1990). Finally, many find it compelling that other species have innate knowledge of biologically important skills and that biological continuity would deem that humans are no different. “All the neonate and infancy data that are accumulating serve to suggest that the nativists have won the battle in accounting for the *initial structure of the human mind*” (Karmiloff-Smith, 1991, p. 173), but the debate continues over whether this innate knowledge is merely enriched during development (Spelke, 1991) or whether new forms are actually constructed through experience (Karmiloff-Smith, 1991).

A further important way in which the maturationist principles of Gesell recur in current developmental work is through the search for genetic continuity in individual differences. Recall that one of Gesell's unwavering beliefs was in the deterministic nature of individual growth profiles from birth, and what he called the “prophetic characteristics of the behavior traits displayed in the first year of life” (Gesell, 1939, p. 307). Many today continue to look for measurable variables in infants that will foreshadow their later cognitive, social, and temperamental qualities. For example, certain aspects of attention, detected in the first months of life, are believed to predict later intelligence (e.g., Bornstein & Sigman, 1986; Thompson, Fagan, & Fulker, 1991). Even more prevalent in the current literature

are studies looking for continuity in personality or temperament. "Personality may be regarded as a pervasive superpattern which expresses the unity and the behavioral characteristicness of the individual," Gesell wrote (1939, p. 304). Many contemporary developmentalists would agree, and they have produced vast numbers of studies tracing the behavioral indexes of stable temperament and its physiological and genetic underpinnings (for review, see Bates, 1987; Kagan, Resnick, & Snidman, 1987). An important goal of Gesell's monumental efforts to describe and norm infant development was early diagnosis, and this effort continues with great vigor, especially with populations at medical or social risk.

Finally, Gesell's influence continues today in behavior-genetic research. The goal of behavioral genetics is to partition that part of the developing child that is biologically prescribed—contained in the genes—from that part that is acquired from the world. Again, the assumption here is that there is something fixed within the organism that mixes to various degrees with the information outside the organism. Sophisticated, longitudinal studies have measured cognitive, temperamental, and social characteristics in twins, nontwin siblings, and adopted children to determine heritability of particular traits (e.g., Plomin & DeFries, 1985; Scarr, 1981). These efforts have led to somewhat murky conclusions: for example, that a large proportion of the variance in behavior cannot be so neatly partitioned (Plomin & Daniels, 1987).

Maturationism and alternative theories. Critics of Gesellian nativism in its pure form and contemporary guises do not dispute the incontrovertible evidence that newborns show organized behavior. What is at issue, however, is the sufficiency of genetic determinism as a developmental explanation. When developmentalists assign causality to autonomous change (maturation), to mental structures that are there from the beginning (innate knowledge), or to factors inherited from parents (genetics), they often stop looking for process, that is, mechanisms of change. As happened to Gesell, this leads to descriptions of what is—what immature organisms can and cannot do, and most important, when they can and cannot do it—and to correlations between typical anatomy and typical behavior and between performance and various degrees of genetic similarity.

Nativism in any form thus leads to a static science, with no principles for understanding change or for confronting the ultimate challenge of development, the source of new forms in structure and function. Process-oriented research has shown that developmental phenomena that was long believed to be phylogenetically determined, such as imprinting or the onset of locomotion, to emerge instead from complex, contingent, dynamic, and multidetermined processes (Gottlieb, 1991; Thelen, 1984). Developmental changes are sometimes engendered from hidden and nonobvious sources or from nonspecific but universal properties of the physical and social environments (Thelen & Fisher, 1982; West & King, 1987).

Second, nativism devalues the active role of animals in their own development. Experiments have shown that from early infancy children begin to behave adaptively through self-initiated, active exploration of their environments (Adolph, Eppler, & E. J. Gibson, 1992; E. J. Gibson, 1988). Current neurophysiological research emphasizes the remarkable plasticity of the developing brain and the role of experience in determining

brain structure, even in adults (Edelman, 1987; Greenough, Black, & Wallace, 1987; Kaas, 1991). Yet we know very little about how infants' everyday encounters with the world shape and mold what has been assumed to be innate. One alternative to innate structures is that the neuroanatomy provides only a rough outline and that the details of brain mappings are etched in through function (Edelman, 1987; Jenkins, Merzenich, & Recanzone, 1990). For instance, there is compelling evidence that even a basic activity such as walking develops as an outside-in process, that is, that stable pathways are discovered by function rather than by autonomous, time-dependent neural changes (Thelen & Ulrich, 1991; Thelen, Ulrich, & Jensen, 1989).

Neonativism also ignores variability and decalage, which must be accounted for in a principled way and cannot be dismissed either as noise, measurement error, or genetic in origin. Just as Gesell's infants often assumed cartoonlike characteristics, the search for genetic universals can make development seem abstract and impoverished. In reality, children have goals, they move, explore, discover, test limits, develop strategies, practice, find alternatives, rely on social partners, and actively engage the world from early infancy. Static descriptions of what children have in their genes or nervous systems cannot capture these various and complex pathways.

Candidates for a process-oriented developmental theory must account for Gesell's observations that behavioral development can appear to be both stagelike and sequential and must have species-typical characteristics yet avoid the pitfalls and sterility of ultimate nativism (Thelen, 1989). Such alternative accounts may thus invoke (a) the child's active perceptual exploration of the environment (E. J. Gibson, 1988), (b) the convergent influence of both the universals of the niche of the developing organism (West & King, 1987) and of specific task requirements (Newell, 1986), (c) the plasticity of the developing brain (Thelen, 1990), and (d) the dynamic, self-organizing properties of biological systems to form stable adaptive patterns without preexisting codes (Thelen, Kelso, & Fogel, 1987; Thelen & Ulrich, 1991).

Gesell's Legacy

It is fitting to conclude with a Gesellian paradox. Gesell himself foreshadowed many of these nonprescriptive accounts of developmental process, although he emphasized his maturational themes so strongly and frequently that these other currents have been largely lost and forgotten. Sections of his book on vision (Gesell, 1946), for example, are positively Gibsonian in their recognition of the preeminence of vision in organizing the world of the infant, and Gesell wrote about the integration of vision and movement in a way not dissimilar from contemporary perception-action theorists (Hofsten, 1985). **He emphasized the totality of the organism and the unity of development in all domains. His descriptions of reciprocal interweaving and the cycles of equilibrium and disequilibrium long predate the current interest in dynamic systems, with their energy flows and oscillatory processes. He likewise recognized the self-righting capabilities of such systems and the processes by which the "organism 'seeks' a maximum in the sphere of behavior" (Gesell, 1933, p. 231), which is again reminiscent of**

current dynamic systems concepts and vocabulary (e.g., Thelen, 1989).

We see Gesell and his influence as full of contrasts and contradictions. His devotion to maturation as the final cause was unwavering, yet he acted as though the environment mattered, and his work contains threads of real process. He believed in the individuality of the child but chose the dictates of the genes over the whims of the environment. He wanted to liberate and reassure parents but may only have added to the arsenal of parental guilt. He was committed to the welfare of children, but in his zeal to classify by age, children often come across as passive and lifeless. He left few acknowledged disciples, yet many today are working within his assumptions. What is not at issue, however, are Gesell's lasting contributions to the field of developmental psychology.

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