

Senescence, Growth, and Gerontology in the United States

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Abstract. This paper discusses how growth and aging became interrelated phenomena with the creation of gerontology in the United States. I first show that the relation of growth to senescence, which had hardly attracted scientific attention before the twentieth century, started to be investigated by several experimental scientists around the 1900s. Subsequently, research on the connection between the two phenomena entered a new domain through the birth of gerontology as a scientific field comprised of various disciplines, many of which addressed growth. Due to gerontologists' efforts, the association between aging and growth became stronger and more multifaceted within the discursive and organizational matrix constituting the new science, leading to a broader definition of senescence with an ambiguous connection to chronological age. Furthermore, as gerontologists borrowed the cultural agendas as well as research methods from studies of growth, aging began to be defined as a phenomenon that could be actively controlled and managed in both social arenas and laboratory environments.

Keywords: Aging, Age, Senescence, Growth, Gerontology, Chronological age

In traditional Western philosophy and medicine, aging and growth were considered distinct phenomena. While both were subjects of academic and medical discourse, few people studied and discussed how they were related. In fact, doctors and naturalists interested in aging could write about senility without knowing much about the process of growth. Although it was obvious that growth and senescence were placed on the continuous passage of time in humans' and animals' lifespan, most physicians and philosophers could not imagine that there were certain connections between the two phenomena.

Historically, the lack of attention to the relationship between aging and growth seems to be rooted in the common conception of the human's life. Few people doubted that humans progressed through several

distinct stages of life, from infancy and childhood to adulthood, middle age, and finally old age. Even today, this way of differentiating the course of life is taken for granted by many people and is used as a means of organizing modern society's institutions, such as schooling, military conscription, and retirement. In general, these phases can be categorized into two major portions, namely, the period of growing up and the time of growing old. In this scheme, the inexorable passage of time implies that aging comes only after a living organism ceases to grow further.

My paper discusses how early contributors to gerontology modified this view in their scientific thinking and practice. I argue that many American researchers of aging in the early and mid-twentieth century experimentally, discursively, and institutionally established the link between growth and senescence. Initially, several prominent biological and medical scientists in the early twentieth century, such as Charles S. Minot (1852–1914), Alexis Carrel (1873–1944), and Aldred Warthin (1866–1931), began to claim that senescence occurred even in developing organisms, including embryos and fetuses. Inspired by these scientists' counterintuitive yet highly inspiring argument, later investigators who would create gerontology in the United States, including Edmund Vincent Cowdry (1888–1975), Clive McCay (1898–1967), and Nathan Shock (1906–1989), further studied the association between the two phenomena and made it a mainline research subject within the organizational and intellectual fabric of their new field.

My study of the scientists' work expands and deepens our understanding of the changing notion of age and aging with the emergence of the science of senescence. As W. Andrew Achenbaum and Stephen Katz have shown, the challenges of aging populations in twentieth century Western society contributed to the establishment of gerontology as a multidisciplinary scientific field which included biology, medicine, psychology, and the social sciences (Achenbaum, 1995; Katz, 1996). Tiago Moreira and Paolo Palladino have also stated that under this multidisciplinary umbrella biogerontology developed as a broad arena dealing with aging as a common underlying factor behind the occurrence of various illnesses, as opposed to biomedicine that became a narrowly delimited discipline organized according to specific disease categories (Moreira and Palladino, 2008). Remarkably, Moreira and Palladino argued, the effort to broaden the scope of gerontology led researchers of aging to doubt the scientific usefulness of chronological age itself, whose relation to degenerative changes in the senile body seemed to them quite ambiguous and contingent. In a similar vein, David Armstrong has claimed that in the twentieth century "the old temporal delimiters of birth

and death have become blurred and natural time has been increasingly stripped from the body” (Armstrong, 2000, p. 258). According to Armstrong, modern medical and scientific ideas and practices regarding growth, senescence, and death steadily decreased the usefulness of chronological age in twentieth century discourses on the body. The present paper expands these claims by examining early gerontologists’ research on growth and senescence. I will show that gerontologists’ investigation of the relationship between growth and aging led them to question the received distinction and temporal order between the two phases in an organism’s lifespan, obscuring the relation of senescence to chronological age.

The current paper also explains how aging, through its connection to growth, came to be recognized in a new way as a controllable phenomenon. In effect, theories of aging in the early twentieth century did not differ much from those of ancient Greece and Rome. While extensive experimental and clinical research on embryos, infants, and children in the early twentieth century led to a plethora of new theories and models on growth and development, senile changes were still a subject of speculation resting upon archaic notions of the decline of “natural heat” or “vital power.”¹ But gerontologists’ study of aging in relation to growth brought forward new approaches that made senescence a controllable and accessible phenomenon. After the mid-twentieth century, American gerontologists began to employ novel techniques and study programs such as tissue culture and caloric restriction, which were thought to enable them to manipulate the aging processes in laboratory conditions.

Significantly, this development accompanied gerontologists’ efforts to control seniors’ lifestyle as well. When the life of children and young animals, like cells in culture medium, were controlled for better adulthood and maturity, the final stages in adult life also increasingly became a target of careful management by gerontologists who aimed at promoting seniors’ activity and better adjustment to modern society. As several scholars have pointed out, however, such an effort often led to a compulsory shaping of the elderly’s life with respect to the norms of industrial or post-industrial capitalism (Katz, 2005; Ballenger, 2006; Cole, 1992). Although the aged were certainly different from children in many respects, both became subject to experts’ coercive measures and recommendations that were hard to refuse in the context of modern Western society.

¹ M. D. Grmek and Richard Grant reviewed various theories of aging up to the early twentieth century. See Grmek (1958) and Grant (1979). However, they did not include more recent developments in gerontology that I will show in this paper.

Growth, Aging, and the Blurred Boundary

Most natural philosophers, scientists, and physicians before the twentieth century were not concerned about the relationship between growth and aging. They attributed bodily decline in old age to the decrease of one critical factor, which usually occurred after growth was completed. From this standpoint, senescence and growth were clearly differentiated in terms of chronology and physiological state. For example, the Hippocratic doctors in ancient Greece wrote that aging was the process of losing “innate heat” (Hippocrates, 1939, p. 294). According to them, “growing bodies have the most innate heat; they therefore require the most food....In older persons the heat is feeble, and therefore they require little fuel.” In this perspective, the amount of the “innate heat” was the key factor determining the boundary between “growing bodies” and “older persons.” Similarly, Roger Bacon (1214–1294), an English philosopher in the thirteenth century, asserted that “natural heat” diminished with aging in “two ways: by the Decay of Natural Moisture, and By the Increase of Extraneous Moisture” (Bacon, 1683). Unlike the Hippocratic doctors, however, Bacon never mentioned growth in relation to the natural heat. Because he advanced this claim for adults who wanted to “cure” old age and “preserve” youth, any changes before the attainment of adulthood were irrelevant.

Many later scholars proposed similar ideas. Christoph Hufeland (1797–1836), a renowned German physician, argued that the enfeeblement of the “vital power, the grand cause of all life” led to aging and natural death (Hufeland, 1797, pp. 35, 63–64). Marie François Xavier Bichat (1771–1802), a leading French physician during the heyday of French clinical medicine, also asserted that aging was ushered in through the weakening of the “internal principle” that resisted the actions of external forces bringing about death (Bichat, 1809, pp. 1–2). Although some scientists introduced variations by arguing that aging was a consequence of the accumulation of waste products or the progressive wearing-out of the body’s components, these theories were not related to growth, either. For instance, the renowned Russian-French scientist Elie Metchnikoff (1845–1916), who coined the term “gérontologie,” thought that aging was a result of accumulated toxic wastes in the body, which was often accompanied by the activities of overly stimulated macrophages that eventually destroyed the constitution (Metchnikoff, 1905, pp. 536–550). Since this change was similar to pathological processes, it could not be expected to take place in healthy young bodies.



Figure 1. The Ascending and Descending Staircase Representing the Human Life. Currier and Ives, *Life and Age of Man, Stages of Man's Life from the Cradle to the Grave*. Created and Published between 1856 and 1907. Library of Congress Prints and Photographic Division, Washington, D.C

That such ideas remained essentially unchanged by the early twentieth century may be explained by the old yet prevalent notion of the life course. It probably did not occur to the aforementioned scholars and physicians that there was more about the relationship between growth and aging, when the dominant view of their time affirmed that each phase in the human's lifespan was unique in terms of physiological characteristics, moral obligations, and religious implications (Cole and Winkler, 1985). While the course of life could be described as either an ascending and descending staircase or an eternal cycle of death and rebirth, it was taken for granted that infancy was inevitably followed by childhood, youth, middle age, and, finally, old age (Figure 1). In this traditional conception, few people could suppose that there was any connection between growth and senescence, which were clearly two distinct processes.

The emergence of a different view was foreshadowed by the development of the life sciences after the mid-nineteenth century, including Charles Darwin's (1809–1882) conception of an evolutionary theory based on natural selection. As has been well documented, Darwin's theory heavily influenced later scientists. Among them, the German zoologist August Weismann (1834–1914) proposed a theory that helped

modify Darwin's idea by ruling out the Lamarckian notion of inheritance of acquired characteristics. According to Weismann, acquired changes were not inherited, because they were registered only in "soma," the part of the body that was not transmitted to later generations (Weismann, 1893). What was important for heredity and evolution was only "germ plasm" containing the true genetic material that would not normally perish and did not change under environmental influences.

Darwin's theory inspired other German researchers as well, especially those who were interested in delineating the evolutionary lineages. In particular, Ernst Haeckel proposed a modified version of the old theory of recapitulation, which postulated that embryogenesis repeated the evolutionary history that Darwin's theory might explain (Haeckel, 1879). To Haeckel and others, Darwin's work demonstrated that it was not meaningful to search for permanent biological types, since the species' form continuously changed over time. Scientists needed to trace humans' and animals' developmental pathways that would show their evolutionary history in a relatively short time (Nyhart, 1995, pp. 105–167; Bowler, 1996; Richards, 1992; Gould, 1977).

Charles Minot was one of the earliest American embryologists who incorporated these emerging biological ideas and practices. Born in 1852, Minot belonged to the first generation of American scientists who imported the new lines of biological and medical research from Germany. At the University of Leipzig, he studied embryogenesis and evolution, and incorporated the rigorous experimental and statistical methods in biology championed by his German colleagues, including his advisor, Carl Ludwig (Minot, 1908, pp. xv–xxii).² At the same time, he studied the theory of recapitulation, which he employed in writing his paper on *Amphioxus*'s phylogenetic tree after returning to America as a professor of embryology at Harvard Medical School (Minot, 1897; Bowler, 1996, pp. 157–171).

It is thus not surprising that Minot's view of aging stemmed from what he learned in Germany. As early as 1886, he fully accepted the idea that the nucleus and the chromosomes were the "physical basis" of heredity (Minot, 1886), which also led him to consider Weismann's argument that senescence and natural death that awaited soma were not inevitable for unicellular organisms or the germ plasm of multicellular species (Minot, 1896; Weismann, 1889, pp. 111, 158–159). While not incorporating Weismann's complex elaboration on evolution and

² For Minot's biography, see Mills (2012).

germinal units, Minot absorbed the German scholar's theory on different cell types and their distinct role and prospect within the organism.³

Yet what appeared more significant for his new theory of aging was his microscopic work at Leipzig, which he continued after moving to Harvard. As Mara Mills has stated, Minot was trained to see the minute cellular changes within sectioned embryos under the microscope, which taught him how to reconstruct the process of aging in a novel fashion (Minot, 1901, p. 494; Mills, 2012). According to Minot, every cell in multicellular organisms underwent a process that he called "cytomorphosis" from the earliest stage of its life cycle, during which the proportion of its cytoplasm gradually increased over that of the nucleus, ultimately resulting in the cell's death. Since the nucleus was the core material of heredity and function, its decreasing proportion implied that the cell was losing its vitality and becoming senile. However, this process turned around right after fertilization, when the nuclear division without increasing the total embryonic volume resulted in a dramatic reduction of the proportion of the cytoplasm in each cell. This phenomenon, which Minot called "rejuvenation," was followed by another round of cytomorphosis during the developmental periods, adulthood, and old age (Minot, 1908, p. 166). The unicellular organism, which did not age, did not need to undergo such a cycle of cytomorphosis and rejuvenation.

But a really novel aspect of Minot's work on senescence is found in his observation of individual animals' growth, which was "more obvious and more accessible to exact study" than any other kinds of changes accompanying age (Minot, 1908, p. xviii). Indeed, this research on individual growth, by focusing on its changing *rate*, offered a new conception that completely reversed the received order of life stages. When it had been generally held that aging was a period of decline, following the phases of infancy and childhood, Minot concluded that the "power of growth," which he thought was revealed through the rate of growth, declined at the highest rate during the earliest phases of life and increasingly slowly in later periods. He conceived this idea by tracing the weight increase of guinea pigs, chickens, and others each day. As the following graph showed, the "daily percentage increments in weight" of the animals diminished most rapidly in their earliest life while the rate of decline gradually decreased as they aged (Figure 2).

³ Minot, (1908, pp. 183, 214–215). The theories proposed by Weismann were not entirely consistent and were subject to various different interpretations (see Moreira and Palladino, 2008; Laubichler and Rheinberger, 2006).

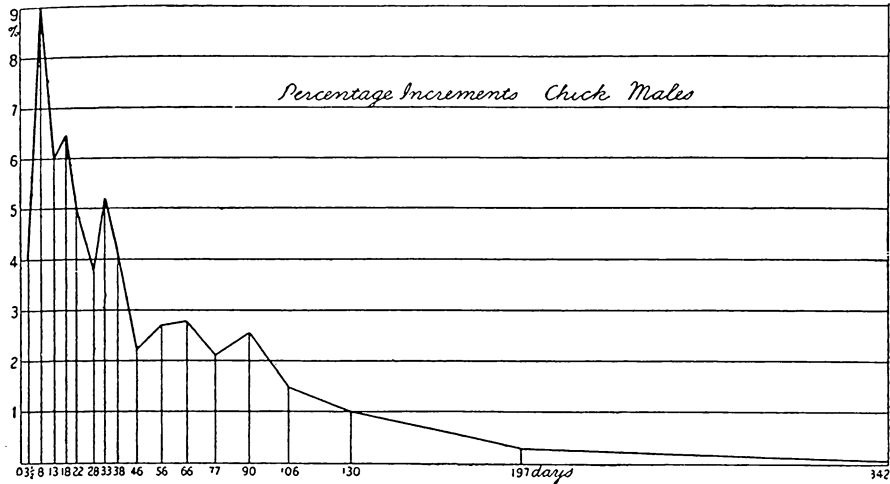


Figure 2. A “Curve Showing the Daily Percentage Increments in Weight by Male Chickens.” Charles S. Minot, *The Problem of Age, Growth, and Death* (London: J. Murray, 1908), p. 101

He thus argued,

...we commonly think of the old as those who have lost most, who have passed beyond the maximum of development and are now upon the path of decline, going down ever more rapidly. One of the chief objects at which I shall aim....will be to explain to you that that notion is erroneous, and that the period of old age, so far from being the chief period of decline, is in reality essentially the period in which the actual decline going on in each of us will be the least. Old age is the period of slowest decline (Minot, 1908, p. 5).

Minot supported this “paradoxical statement” with other examples as well. He wrote that the rate of decline of humans’ “learning power” was highest during their early life and became increasingly lower in the following periods (Minot, 1908, p. 243). Similarly, cell death, which was necessary for morphogenesis, occurred at the highest rate during embryogenesis and at increasingly lower rates in the later parts of life. All these pieces of evidence indicated that growth was inextricably intertwined with rapid decline and degeneration in early life.⁴

⁴ Based on this conclusion, he held that old age came much earlier than usually thought. Therefore, he argued, it was necessary to begin education and vocational life as early as possible. He even asserted that people after twenty-five might not be quite useful or creative due to aging (see Minot, 1908, pp. 245–246). Although many gerontologists were very favorable to Minot’s idea on growth and senescence, few of them accepted this part of his claim.

How was this view received? Certainly, some scholars could not accept it. For instance, Herbert Spencer Jennings, a John Hopkins zoologist who would study the aging of protozoa and rotifers, stated that “the decline in growth and the later decline in effectiveness...are evidently not identical.”⁵ However, a majority of researchers interested in senescence as a scientific subject were favorable to Minot’s work.⁶ To most of them, Minot offered an interesting paradox that demanded further scientific examination. If possible, it was desirable to track the actual bodily decline at the level of cells, which should be young but also dying and degenerating at the same time.

For this purpose, biological scientists found the technique of cell culture an adequate research tool with the growth of experimental embryology, a new biological subdiscipline born in the late nineteenth century.⁷ By elucidating the characteristics and causes of development through the manipulation of very young animals, experimental embryologists forged a novel instrument for studying the cell’s aging as well as maturing.

In this new venue of investigation, the American embryologist Ross Harrison (1870–1959) initially played an important role, although the French surgeon and Nobel laureate Alexis Carrel would soon make a more significant contribution. In 1906, Harrison, a professor at Johns Hopkins, succeeded in keeping nerve cells extracted from frog embryos alive for four weeks (Harrison, 1906). This experiment and other works enabled him to offer his answers to the questions on nerve fiber development, a controversial problem in embryology (Harrison, 1910). Yet it was Alexis Carrel at the Rockefeller Institute for Medical Research who further refined the technique for tackling questions relevant to gerontology. After moving from France to Canada and then to the United States, Carrel imported Harrison’s new tissue culture technique to investigate the interaction between tissues and their medium with re-

⁵ Jennings (1909). For Jennings’s research on aging, see Jennings (1928). Jennings was a contributor to Vincent Cowdry’s *Problems of Ageing* (1939), a key factor for initiating gerontology’s growth in America. See Jennings (1939).

⁶ In addition to the scholars I mention in his paper, see Vladimir Korenchevsky, Report of Dr. Korenchevsky to the Medical Research Council for 1941–1942, 3 Nov 1942, the National Archives of the United Kingdom, London, England [hereafter NAUK], FD 1/675 (Korenchevsky’s Research, 1942–1953, p. 4; Cohn and Murray, 1927, p. 473; Stieglitz, 1941, p. 1385).

⁷ The origin of experimental embryology and its relation to “descriptive embryology” have been a subject of intense historical research (see, for example, Allen, 1975; Maienschein et al., 1981; Maienschein, 1991; Gilbert, 1991; Nyhart, 1995, pp. 243–337; Hopwood, 2009, pp. 298–304). On Ross Harrison’s experimental embryology (see Witkowski, 1985; Maienschein, 1983; Landecker, 2007, pp. 28–67).

spect to regeneration, immortality, and senescence. Even though Carrel, as a surgeon by training, initially adopted tissue culture for studying his long-time subjects such as surgical reconnection of tissues and organ transplantation (Landecker, 2004; McKellar, 2004), it evolved into a means of addressing new questions through controlling managing growth.

Carrel's tissue culture engendered several challenging issues for later scientists of aging. First, he found that the rate and vigor of cells' proliferation depended on the characteristics of their medium, especially the *age* of the organism that provided it (Carrel and Ebeling, 1921). The older the organism was, the less efficient the culture became. Second, each type of cells seemed to have an optimal medium for growth (Carrel and Burrows, 1911; Carrel, 1924; 1931a). If such a medium was provided, cells would have the best opportunity for survival. Third, there appeared to be a special way to enable cells to overcome aging completely and live indefinitely. According to Carrel, cellular aging and death *in vivo* was due to the accumulation of their metabolic wastes that lowered the quality of their surroundings. When he periodically removed such wastes and gave fresh nutrients of an optimal condition to the cells in culture, they, he claimed, could become "immortal" and live almost permanently without undergoing senile changes.⁸ In 1911, he thus argued that "senility and death of tissues are not a necessary phenomenon and that they result merely from accidental causes" (Carrel, 1911).

Although Carrel's immortality argument came to be questioned and challenged (Hayflick and Moorhead, 1961; Witkowski, 1980), he exerted a considerable influence upon the prospective gerontologists in the 1930s and the 1940s.⁹ To them, Carrel's work demonstrated that aging was a contingent phenomenon that could be experimentally manipulated. Although it was still impossible to rejuvenate or totally prevent the aging of the whole body, it appeared at least feasible to do something about aging at the level of cells. This prompted several renowned scientists to take the earliest steps toward creating gerontology as a field of study, and some of them—such as Henry Simms, Peter

⁸ For a historical analysis of Carrel's immortality argument, see Landecker, 2007, pp. 68–106.

⁹ Together with the cases that I discuss here, see Lawrence Frank to Carrel, 14 May 1938, Alexis Carrel Papers, Georgetown University Archive, Washington, D.C. [hereafter AC], Box 66, Folder 3; Alfred Cohn to Carrel, 5 December 1940, AC, Box 41, Folder 22; Stieglitz to Carrel, 26 June 1940, AC, Box 69, Folder 27; MacNider to Carrel, 7 April 1931, AC, Box 58, Folder 88.

Medawar, and Peter Leslie Krohn—adopted tissue culture as a major laboratory technology in their investigation of senescence.¹⁰

Carrel's study of the impact of culture media upon cellular growth and aging was another important influence upon later scientists of senescence. To them, the distinct behavior of Carrel's cultured tissues in different media bespoke the actual state and future of cells *in vivo*, including their patterns of growth and aging. Indeed, based on his tissue culture, Carrel himself stated briefly that "each type of tissue appears to record time in its own way" because their "physiological time," as opposed to "physical time," was recorded through changes in cells in accordance with the state of their environments (Carrel, 1931b, pp. 619, 621). This idea challenged the traditional theory that the whole body underwent senile changes uniformly with the decline or decay of a single critical factor such as "vital power."¹¹ To Carrel and later researchers, aging was a localized phenomenon, because cells in the body would grow and age at a distinct speed, depending on their ambient fluid environment.

Interestingly, many of Carrel's experiments relied on young, rather than old, cells. Like Harrison, Carrel chose embryonic tissues for his longest-running culturing project that enabled him to claim that cells could become immortal under ideal conditions. Although he also used cells from older animals in some of his studies, many of his investigations relied on embryonic tissues as the sole research subject. In this context, it is meaningful to note that even Leonard Hayflick, who criticized Carrel's immortality argument during the 1960s, used fetal cells in his renowned experiments on the inevitable death of cultured somatic cells (Hayflick, 1965). We can thus say that Carrel's and Hayflick's work entailed an ironical situation, as they investigated old age through very young cells. Yet this irony rearticulates how aging and growth became intertwined in twentieth century biology and medical research.

¹⁰ Henry S. Simms, Abstract of Presentation at the Meeting of the Club for Research on Aging, 13 February 1943, Nathan W. Shock Papers, Bentley Historical Library, Ann Arbor, Michigan [hereafter NWS], Box 30, Folder Club for Aging 1943, Feb; Peter Leslie Krohn, "The Nuffield Foundation: Nuffield Gerontological Research Fellowship, Proposals for Research," Nuffield Foundation Archive, London, England, Box NF AGE1, Folder Age 18 Nuffield Gerontological Research Fellowship, pp. 3–6; Medawar, 1940.

¹¹ See Minot, 1908, pp. 214–216; Cohn and Murray, 1927; Pearl, 1922, pp. 138–149; A. J. Carlson to Cowdry, 28 Jun 1937, William deB. MacNider Papers, Call Number 837, Manuscript Department, Wilson Library, University of North Carolina, Chapel Hill, North Carolina, Box 10, Folder 397.

The correlation between the two phenomena could also be found in Carrel's social thoughts expressed in his best-selling monograph, *Man, the Unknown* (1935). In this controversial book, Carrel pointed to the problems of growth and aging as a part of the multilayered troubles of his time. To Carrel, both childhood and old age were endangered in modern society that was not ideal for proper human development and fruitful later life. For instance, he argued that "the silly programs of public entertainment" impeded the sound mental development of children while the stressful work environment and the desire to look young often caused severe moral deterioration and sudden death of the middle-aged or the elderly (Carrel, 1935, pp. 152, 179). In fact, these issues contributed to a more profound crisis of the Western civilization with the coming of the Great Depression and the enhancing problems of crime, delinquency, and moral corruption. In such a state, Carrel claimed, a wholesale reexamination of the nature of men and their environment was needed for a redesigning of the social order which could demand certain drastic measures such as involuntary euthanasia. Pursuing this urgent new venture, Minot's discovery that "aging progresses much more rapidly at the beginning than at the end of life" was probably not a negligible fact (Carrel, 1935, p. 169).

This statement was meaningful in his own laboratory as well as in broader social arenas.¹² According to Carrel, "the index of cicatrization and the growth index of blood serum undergo at the beginning of life a rapid decrease which later becomes slower" (Carrel, 1931b, p. 620). Here, the "index of cicatrization" meant the rate of wound healing measured in terms of scar formation, and the "growth index of blood serum" was the degree that the blood serum as culture medium stimulated cellular growth in laboratory conditions. Carrel noticed that "the curves representing these indexes slope downward very sharply during youth" whereas "they are almost horizontal" in the final phases of life. With this observation, it could not be denied that "aging starts simultaneously with embryonic life" and became ever slower as time went on.

But one may wonder how Carrel's idea on the immortality of cells could be rendered compatible with Minot's conclusion on the inevitability of cellular degeneration and death. Curiously, Carrel himself did not appear to worry deeply about this problem. Probably, this was because cellular immortality that he advocated was to be seen only in an ideal laboratory condition while cells in vivo underwent a consistent senile process as claimed by Minot. Yet Carrel's contemporaries did not

¹² Perrin Selcer has analyzed Carrel's vision of the biological and the social in his research on wounds and discourses on management (See Selcer, 2008).

always view the subject in such a way. Raymond Pearl, who regarded Minot's claim as a general theory on all somatic cells' ultimate destiny, flatly rejected it, because plant cells and protozoa as well as Carrel's chicken cells demonstrated that "life itself is inherently continuous" (Pearl, 1922, pp. 48, 71). On the other hand, Medawar wrote that Minot might be closer to the truth, although he found it difficult to refute Carrel's statement as a whole (1942, p. 593). Perhaps Carrel might eventually turn out to be right, but Minot's assertion accorded well with Medawar's own tissue culture that demonstrated a rapid decline in embryonic cells' doubling rate as a result of their "senescence" (Medawar, 1940).

While such differences in perspective could not be easily reconciled, it was true that Medawar's standpoint fit with what many embryologists had been consistently discussing after the mid-nineteenth century. Indeed, as Hannah Landecker has stated, "embryologists had long studied developmental moments in which cells disappeared in the process of making new structures" before the advent of modern studies of apoptosis or programmed cell death (Landecker, 2003, p. 28). Through embryologists' efforts, various organs' and tissues' degeneration accompanying growth was known, although at the time it was often framed within the old theory of recapitulation. For instance, in 1879, Haeckel wrote that during the metamorphosis of tadpoles to frogs "the gills, with the gill-vessels, are entirely lost" and "the long tail is also rejected" as a part of the recapitulation of an evolutionary change (Haeckel, 1879, p. 128). For him, this was a case showing how the frog's ontogeny repeated the evolutionary transformation from fish to amphibians in a short time span. As the recapitulation theory underwent a considerable revision during the following decades (Gould, 1977, pp. 186–206; Maienschein, 1978), however, this phenomenon assumed a totally different meaning, especially through the theoretical insight of Aldred Scott Warthin.

Warthin was a medical researcher at the University of Michigan interested in cancer and other chronic diseases in middle and old ages (Baugh, 1987; Lynch, 1985). Due to his institutional position and research orientation, he was concerned more about health and illness of aged patients than evolutionary questions that had fascinated Haeckel. In particular, Warthin was curious about the distinction between senile changes and pathological transformations, a longstanding controversial issue in medicine (Schäfer, 2002; Grob, 2011; Hirshbein, 2000). How could a doctor distinguish a sign of chronic diseases from a normal senile change? Were the symptoms of old age a kind of pathological alteration? It seems that his view of senescence sprang from these

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Germinal	Loss of half of chromatin content.
Conceptional	Tail of Spermatozoon. Polar bodies of ovum.
Embryonic	Gill slits. Thyreoglossal duct. Postbranchial bodies. Branchial vessels. Craniopharyngeal duct. Notochord. Wolffian body and duct. Pronephros. Müllerian duct. Omphalomesenteric duct. Postanal duct. Tail. Supernumerary mammary anlage.
Fetal	Organ of Jacobson. Zuckerkandl organs. Tunica vasculosa lentis. Plica semilunaris. Chorionic vessels. Chorionic villi. Lanugo.
At Birth	Amnion and Placenta. Umbilical cord. Foramen ovale.
Following Birth	Umbilical vessels. Urachus. Ductus arteriosus. Lanugo.
Childhood	Sucking disk. Milk teeth. Absorbent organ. Interscapular hemolymph nodes.
Puberty and Early Adult Life	Thymus. Tonsils.
Functional	Involutions of Uterus, Breasts, etc.

Figure 3. "The Minor Involutions of Development." Aldred Warthin, *Old Age, The Major Involution: The Physiology & Pathology of the Aging Process* (New York: Hoeber, 1929), p. 58

questions as he discussed during the Wesley M. Carpenter Lecture of the New York Academy of Medicine in 1928. In the following year, he published this lecture as a monograph, *Old Age: The Major Involution* (1929).

In the book, Warthin stressed that aging was a physiological rather than pathological phenomenon, because it occurred constantly even in healthy, growing bodies. This "aging" during development, which was essential for normal morphogenesis, should be called the "minor involutions," as opposed to the "major involution" that was the senile changes in old age. According to Warthin, the earliest instances of the minor involutions were the degeneration of the tail of spermatozoa and the polar bodies of the ovum right after fertilization. The subsequent growth process entailed further minor involutions. As Haeckel had already noted, the gill slits and the notochord disappeared during embryogenesis. In the postpartum period, additional minor involutions took place, especially in the umbilical vessels which quickly became degenerate through rapid senescence after finishing its role. Significantly, some minor involutions occurred even during puberty and early adulthood, such as the atrophy of the thymus and tonsils (Figure 3).

In other words, Warthin wrote, "growth and retrogression [went] hand in hand in the broad economy of the organism" (Warthin, 1929, p. 69). Yet these minor involutions were "prophetic of the future fate of the organism as a whole." Although only a certain portion of the body underwent aging and death during development, the entire body would eventually become senile and degenerate through similar processes.

Warthin did not have a chance to delve into this topic, because he died two years after publishing his book. In the 1930s, however, aging began to be highlighted as a subject worthy of serious scientific inquiry. Although Minot was then dead and Carrel became substantially less productive, a group of younger scientists started claiming that aging deserved more intensive and careful attention. Through their initiative, the first academic conference on aging was held at Woods Hole, Massachusetts in 1937, and the Russian-British scientist Vladimir Korenchevsky organized the Club for Research on Ageing as a small informal research group for students of senescence not only in Europe but also in America. Then, Carrel also discussed the need for “an institute dedicated to the study of the process of aging” in one of his public talks in 1937.¹³ In general, motivated researchers began to organize research revolving around aging, which, they claimed, ought to be institutionalized and systematically supported. The following sections will show how this movement furthered the study of the linkage between growth and aging.

The Young, the Aged, and the Making of Gerontology

The birth of gerontology in the United States was in part a response to a social crisis, the Great Depression. During the worldwide economic collapse, the earliest attempt to create a field for aging research was made by Vincent Cowdry and his colleagues who thought that scientific knowledge was indispensable for a proper management of the elderly’s predicaments of the time, such as poverty, unemployment, and ill health (Park, 2008; Gruman, 1979, pp. 4–5). In effect, these problems arose with the 1929 stock market crash that agitated many industrialized countries in the Western World. In particular, when the employment opportunities were cut drastically, the chance of losing a job was deemed higher for the old than the young. Furthermore, the destruction of most private pension plans with the bankruptcy of major financial institutions deprived the elderly of their last means of livelihood. As a response, the federal government of the United States passed the Social Security Act, which included a plan for providing seniors with a basic income.¹⁴ Yet a number of scientists thought that the law was not

¹³ Alexis Carrel, “The Problem of the Prolongation of Life,” 3 December 1937, AC, Box 23, Folder 15.

¹⁴ The varied political and social backgrounds of making the law have been studied by historians (see Achenbaum, 1986, pp. 13–18; Graebner, 1980, pp. 181–214; Haber and Gratton, 1994, pp. 172–185).

enough to deal with the current problems. Did the elderly really show considerable physiological and psychological decline that made them unfit for continued employment? What were the best ways to maintain their health and vigor despite the apparently advancing chronological age? Since it was held that the true answer to these questions should only be found with an organized multidisciplinary investigation, a group of scientists initiated a movement for constructing gerontology.

It is notable that the concern for the aged was preceded and accompanied by the rise of the sciences of growth in America. From the mid-nineteenth to the early twentieth centuries, professionalizing medicine and science, expanding mass-education, and increasing cultural anxiety over urbanization and immigration highlighted children as a key object of attention for the nation's future (Markel, 2004; Brosco, 2004; Prescott, 2004).¹⁵ Gradually, a more integrated movement for studying children began in the 1920s through the initiative of a host of activists and scholars, including Lawrence Frank and his associates in the Laura Spelman Rockefeller Memorial (LSRM) (Smuts, 2006, pp. 139–154). The movement was uniquely American, without any counterparts in other countries, and deeply multidisciplinary, with diverse participants tackling various aspects of growth, including psychologists, economists, sociologists, physiologists, nurses, and physicians. According to historian Nathan Crowe, another important movement for studying growth was promoted by cancer researchers. Motivated by the idea that understanding cellular growth was a clue to unlocking the nature of cancerous growth, these researchers invited professional investigators from many fields – such as genetics, embryology, botany, and anthropology – to launch a new journal, *Growth*, in 1937 and the Society for the Study of Development and Growth in 1940 (Crowe, 2011, pp. 34–61).

It is significant that many scholars involved in these movements were instrumental in creating the multidisciplinary science of gerontology. Remarkably, the relationship between aging and growth was occasionally mentioned during the symposia of the Society for the Study of Development and Growth (Oppenheimer, 1966, pp. 18, 20). But what was more important was the fact that a number of early gerontologists participated in the movement for studying growth before joining the field of aging research. For instance, Frank, who was an LSRM officer and an editorial board member of *Growth*, became the Josiah Macy, Jr. Foundation's vice-president, taking charge of its funding program for researchers of aging. His interdisciplinary vision on child studies

¹⁵ While not a student of child growth, embryologist Edwin Conklin's view should also be relevant (see Cooke, 2002).

continued when he approached aging as a “multi-dimensional problem,” corresponding to other scientists’ hope that gerontology should be a multidisciplinary science reflecting the manifold problems of aging, including age discrimination, psychological adaptation, and biological changes underlying various chronic illnesses.¹⁶ T. Wingate Todd, an early participant in American gerontology in the 1930s, was also an expert in research on bone growth and chair of the National Research Council’s Committee on Child Development under the sponsorship of the LSRM (Smuts, 2006, p. 157; Todd, 1937). Similarly, Nathan Shock was a renowned student of child growth before turning to gerontology as chief of the Unit on Gerontology in the National Institute of Health (NIH) in 1941. The campaign to advance research on growth represented the starting point for many scientists who would embark on investigating senescence.

Another productive line of studying aging was spearheaded by Clive McCay, a scientist of animal husbandry at Cornell University. It is notable that he was already fascinated by Carrel’s research and its implications for growth and aging when he was a graduate student at the University of California. In 1924, he wrote to his fiancée about “the cells of the chicken heart” that had “been kept in a healthy living state without a sign of deterioration for three times the [life] of the chicken.”¹⁷ The long life of Carrel’s cells in culture indicated that science might prepare a way to control “senility...[that] persists in dogging our steps from the time the ovum is first fertilized.” Fortunately, McCay acquired an opportunity to find such a way through his own research on growth, when he started his professional career after finishing his education. At Yale, and then at Cornell, his team discovered that animals whose growth was retarded due to inadequate diets with low caloric content eventually lived longer than the controls, probably because of their delayed aging (Titcomb et al., 1928; McCay and Crowell, 1934). According to McCay, this discovery revealed a wrong practice prevalent among farmers and breeders, that is, expediting farm animals’ growth to save time and money. Although he noted that “the nutrition of animals that are to be slaughtered for meat shortly after they mature should be considered from the point of view of rapid growth,” he claimed that other animals – such as hens, dairy cattle, and horses, which provided humans with eggs, milk, and labor – should be raised slowly to increase

¹⁶ Lawrence Frank, “Comments on the Problem of Ageing,” 12-13 January 1940, NWS, Box 11, Folder Admin. Files E. J. Stieglitz 1939-41 I, p. 11.

¹⁷ McCay to Beyer, 27 April 1924, Clive Maine McCay Papers, Cornell University Archive, Ithaca, New York, Box 50, Folder CMM Letters 1923-1927.

longevity and retard the onset of aging (McCay, 1933, p. 411). Despite such a practical implication for breeding, however, the impact of McCay's work was greater upon the emerging field of gerontology than animal husbandry (Comfort, 1956, p. 148; Masoro, 2002, pp. 2–3). As I have discussed elsewhere, his work on underfed animals led to a multidisciplinary research program on the relation of caloric intake to senescence and longevity, which created a novel means of the experimental control of aging processes (Park, 2010).

McCay's association with gerontology started with his contribution to Vincent Cowdry's *Problems of Ageing* (1939), the first American multi-authored handbook on senescence, which led to the establishment of the Club for Research on Ageing and the Gerontological Society (Achenbaum, 1995, pp. 52–84; Katz, 1996, pp. 93–103). Cowdry was a cytologist at Washington University and a longstanding editor of several major textbooks and handbooks in biology and medicine. To him, multi-authored books were an ideal means to mobilize a broad range of expertise on complex subjects, such as arteriosclerosis, human biology, and the nature of the cell. With this view, he turned to the problems of aging, which he thought urgently demanded extensive and multifaceted scientific approaches for an adequate treatment of the varied social and medical problems regarding the elderly during the Depression (Park, 2008). He thus decided to publish *Problems of Ageing* as his next handbook and invited the best American researchers of senescence, including McCay who had written several interesting articles on longevity and caloric intake.¹⁸ As a junior scientist, McCay gladly accepted the offer, because writing a chapter in Cowdry's book would enable him to interact with renowned senior scholars and promote his work in the scientific community.

It was no coincidence that many people McCay would meet during the editorial process had experience in the field of studying development and growth. Most of all, Lawrence Frank, the key person in the Macy Foundation supporting the publication of *Problems of Ageing*, had been involved in encouraging the study of growth. Students of growth were among the contributors as well. Along with McCay, Cowdry recruited Todd, who wrote a chapter on the senescence and growth of the "skeleton, locomotor system, and teeth." Alfred Cohn, a cardiologist at the Rockefeller Institute, also joined the author group after investigating the proliferation of embryonic chicken heart cells (Cohn and

¹⁸ McCay to Cowdry, 30 November 1936; Cowdry to McCay, 12 December 1936, Edmund Vincent Cowdry Papers, Bernard Becker Medical Library, Washington University, St. Louis, Missouri [hereafter EVC], Box 32, Folder 21.

Murray, 1925). Statistician Louis Dublin at Metropolitan Life Insurance Company was another prominent contributor who was known for his statistical analysis of children's health and weight in accordance with their age (Dublin and Gebhart, 1923). Likewise, Earl Engle at Columbia University became an author after his renowned study of the impact of anterior pituitary hormones on the infantile gonad's maturation.¹⁹

With regard to growth and development, Cowdry's standpoint was not significantly different from that of the researchers he invited to contribute to *Problems of Ageing*. Most significantly, Cowdry incorporated Carrel's view of growth and aging, especially when he stayed at the Rockefeller Institute.²⁰ As I have written, Carrel thought that the proliferation and senescence of tissues depended on their culture medium. Following this idea, Cowdry postulated that the rate and mode of aging differed in each part of the body because of its distinct "local tissue fluid environment" (Cowdry, 1939, pp. 686–690). To each cell, Cowdry thought, this local environment constituted the immediate surrounding through which vital nutrients were provided from the bloodstream. Simultaneously, the local environment prevented the homogenizing influence of the blood and the lymph, enabling the cells to grow and become senile at their own rate regardless of the organism's chronological age. For instance, he argued, "the arteries of the placenta become old and senile in less than nine months" within their unique surrounding, while the aging of other organs took place in an individual's later life (Cowdry, 1933, p. 63). In his chapter in *Problems of Ageing*, he also stated,

....the burden of years is not evenly felt by blood vessels of all sorts. In addition to such local differences in susceptibility remarkable differences in speed of operation of the ageing processes are noted. To cite only a few instances, the umbilical artery lasts but a short time, the ductus arteriosus becomes senile a few months after birth and the uterine arteries are rejuvenated with each pregnancy (Cowdry, 1939, p. 665).

Aging could be observed in tissues and organs taking charge of the earliest moments in life.

With this idea in mind, Cowdry published *Problems of Ageing*, which stimulated, along with Korenchevsky's efforts, the formation of the American Club for Research on Ageing (Park, 2008). Significantly,

¹⁹ John Lattimer, "Eulogies to Earl T. Engle," Earl T. Engle Papers, Columbia University Archive, New York, New York, Box 1, Folder 1 Eulogies, 1958–1959.

²⁰ Cowdry continued to interact with Carrel even after he left the Rockefeller Institute. See, for example, Cowdry to Carrel, 13 April 1929, EVC, Box 159, Folder 5.

many of the early members of the club, who were contributors to *Problems of Ageing*, were interested in the relationship between growth and aging and discussed it during the first meeting in 1940. Indeed, Korenchevsky, who organized the club in the 1939, recommended that a member who was “working on young and adults” should “include in his research some experiments on old animals and patients” as well.²¹ But many of the attendees took a further step and studied more fundamental issues on growth and senescence, which they came up with during the meeting. For example, Cohn commented that “the word ‘ageing’ itself is unfortunate since this process begins at birth.”²² Clearly, there had to be a different word to describe the complexity inherent to the interrelated phenomena of aging and growth, as his own work on the cardiac cells of chicken embryos indicated. W. A. Allen, an obstetrician at Washington University, pointed to more concrete topics in medicine and biology. According to Allen, it was noteworthy that the “placenta must undergo an ageing process before the baby is born.” Moreover, he continued, “the problem of the menopause is probably analogous to that of adolescence except that the two are the end and the beginning of sexual life.” To this remark, Engle added that “the first three or four years in the development of the menstrual cycle [are] probably entirely comparable to the period in life when the cycle gradually disappears.”²³

McCay continued the discussion on growth and senescence by introducing his own work on the impacts of retarded growth on senile changes in rats.²⁴ To him, this was a good opportunity to promulgate the significance and broad relevance of his research to the early community of gerontologists, some of whom would decide to investigate McCay’s subjects further using the rats that he distributed free of charge (Park, 2010). For them, McCay’s modulation of the process of growth engendered many intriguing research problems manifested through the distinct responses of each part of the body toward reduced caloric

²¹ Korenchevsky to Cowdry, 28 August 1939, EVC, Box 41, Folder 12. It is notable that Korenchevsky, too, did an experiment supporting Minot’s claim. See Report of Dr. V. Korenchevsky to the Medical Research Council for 1941–1942, NAUK, FD 1/675 (Korenchevsky’s Research, 1942–1953).

²² Meeting of the Club for Research on Ageing, 11–12 January 1940, EVC, Box 41, Folder 2, p. 10.

²³ The physiological similarity between development and senescence was a topic attracting many medical scientists (see Armstrong, 2000, pp. 250–251).

²⁴ Meeting of the Club for Research on Ageing, 11–12 January 1940, EVC, Box 41, Folder 2, p. 12. Also see Minutes of the Meetings of the Club for Research on Ageing, 21–22 March 1941, EVC, Box 41, Folder 2.

intake. To understand these phenomena more thoroughly, McCay and his multidisciplinary colleagues – coming from physiology, physics, biochemistry, dentistry, and psychology – pursued systematic research on the impact of reduced dietary calories on growing and aging organisms (Lowry et al., 1942; Smith et al., 1939; McCay et al., 1939; James and McCay, 1944).

The relationship between growth and senescence was often revisited throughout the club's meetings. In 1943, for example, Ross Harrison attended the meeting and talked about the implications of Carrel's immortal cells for the process of senescence along with the broader meanings of cultured tissues' growth for understanding age changes. After this talk, Henry Simms discussed his own tissue culture experiment that challenged Carrel's conclusion. In contrast to Carrel's investigation, Simms's research using chicken's aorta and plasma showed that "the older tissues grew sooner....and faster than the one year tissues" and "the older plasmas supported growth sooner and faster than the young plasmas."²⁵ Whereas Simms himself admitted that "I do not know how to explain" this result, his work provoked a deeper discussion on the relationship between tissue growth in vitro and the aging process in vivo. Frederick Hisaw at Harvard University was another important commentator on the matter in 1943. After a short review of the mechanisms of embryogenesis including the role of organizers, he said that "in later life there is perhaps a similar process."²⁶ Since senescence was "something that starts at the fertilization of the egg," a continuous process of induction and conditioning through organizer-like or hormone-like chemical agents could be responsible for the symptoms accompanying aging. A more thorough study of this process was necessary for a rigorous analysis of the mechanism of senescence.

The Macy Foundation, the philanthropy that financially sponsored the club, was highly favorable to the topic, as could be seen in its "Life Cycle" program designed according to the broadly conceived idea of aging and growth. Based on the "time-honored and still meaningful emphasis upon the life history of the individual and the species," the foundation decided to support "studies in genetics, the process of heredity, ovulation, embryology, growth at different stages of life, child development, maturation, and problems of aging" (Josiah Macy, Jr. Foundation, 1955, p. 71). It is meaningful to note that several early

²⁵ "Abstract of Presentation at the Meeting of the Club for Research on Aging," 13 February 1943, NWS, Box 30, Folder Club for Aging.

²⁶ "Club for Research on Ageing, Secretary's Report by Robert A. Moore," 13–14 February 1943, NWS, Box 30, Folder Club for Aging 1943, Feb, NWS, p. 9.

gerontologists were funded under this program along with a host of scholars and physicians studying fertilization, embryogenesis, and child growth. For example, the foundation funded Gregory Pincus's study of mammalian eggs at Harvard University and John Whitehorn's project on child growth at Johns Hopkins, together with Henry Simms's research at Columbia University on arteriosclerosis and aging. The Foundation also underwrote the cost of John Saxton's pathological research using McCay's rats as well as William deB. MacNider's investigation into the age-changes of cellular resistance against toxins (Josiah Macy, Jr. Foundation, 1950, pp. 36–37). Cowdry's work on the aging of skin and endocrine glands was another important project the foundation supported.

One of the main administrators who steered this funding policy was Lawrence Frank. As vice-present of the foundation, he played an important role in organizing its programs for gerontology. This work, along with his contribution to the birth of the NIH Gerontology Unit, bespeaks the organizational, institutional, and cultural concatenation between growth and aging after the creation of gerontology.

Raising Children and Managing Seniors: Gerontology, Institutions, and the Human Development

Frank had a profound interest in both growth and aging from the perspective of the entire lifespan. As I have mentioned briefly, this perspective was derived from his earlier work at the LSRM for the study of childhood and adolescence. Frank then thought that the sciences of growth should produce knowledge for raising children who would grow up and contribute to creating healthier and stronger society. This vision was supported by the emerging cultural concern on childhood, especially during and after World War I which showed that a large number of young people were unfit for military service probably due to their inadequate childhood. In the 1920s, a decade of an optimistic economic outlook and confidence in the power of science, Frank and his colleagues thus claimed that it was necessary to have reliable and thorough knowledge on providing the best education and parenting available for those in their formative years. Noticeably, Frank defined growth very broadly, as the long period from conception to maturity (Smuts, 2006, p. 158). After leaving the LSRM, he extended the scope of his interest even further to include old age as the final phase of human's maturation rather than the time of decrepitude and obsolescence (Frank, 1947).

Frank interacted with gerontologists not only as a foundation officer but also as a regular member in the growing academic community. The following comment during the first meeting of the Club for Research on Ageing illustrates what he eagerly wanted to share with other gerontologists interested in aging and growth.

For many years the writer has been concerned with the study of child growth and development in an endeavor to further the understanding of the processes by which the individual organism moves from conception through infancy, childhood, and adolescence to early adult maturity....it became apparent that the same questions are involved in a study of ageing and senescence, as in the study of child growth and development. It may be of interest, therefore, to point out....what light has been thrown upon them by those who have been studying children.²⁷

He stated that physiological age, which might differ from chronological age, had been measured by students of childhood in the earlier decades (Prescott, 2004; Crampton, 1908). This could be adopted in studying senescence to determine the actual degree of aging in terms of physiological capacities. The longitudinal observation method – which traced a person's age changes over a long time span – for investigating the process of growth should also be a useful way of revealing the characteristics of senile alterations in an individualized manner.

In 1946, Frank stated his view of the relationship between growth and aging more clearly in a periodical the Macy Foundation sponsored – the *Journal of Gerontology*, the first official publication of the Gerontological Society.²⁸ His paper, titled “Gerontology,” occupying the first eleven pages in the journal's first volume, held a programmatic statement indicating the current state and the future direction of the new society. Frank discussed several major issues in the science of aging, such as the importance of experimental approaches and the economic and political problems of retirement. Among them, Minot's idea could not be omitted. Frank wrote that “as Minot pointed out and as other investigators have been showing, the aging process is operating early in life and sometimes most rapidly in infantile or juvenile organisms and in the fetus” (Frank, 1946, p. 5). Furthermore,

²⁷ Lawrence Frank, “Comments on the Problem of Ageing Presented to the Meeting of the Club for Research on Ageing,” 12–13 January 1940, NWS, Box 30, Folder Club for Aging 1940.

²⁸ Gerontological Society, Inc. Financial Statement, 15 February 1946, NWS, Box 30, Folder Club for Aging 1946, Feb. Also see Adler (1958, p. 97).

Frank added, “some of the most accessible cyclic processes of the adult mammalian organism involve aging, as shown by the monthly growth, maturation, and involution of the ovarian follicle and of the endometrium and also in the development and aging of the placenta.”

What did all these findings mean for scientists of growth and aging? Frank explicitly stated that “today we must realize that the study of aged and aging cells cannot mark the boundary of our inquiries.” Because living organisms were constantly changing its constituent during its entire lifespan, it was significant to “approach more closely the dynamics of the basic living process wherein these subtle and as yet unmeasured alterations....give rise not only to growth, development, maturation and aging, but apparently also to individual variability and pathological deviations.” Hence, researchers interested in one of these subjects or their correlations would substantially benefit from joining gerontology whose scope should cover all of them. Gerontology was “an enterprise calling for many and diversified studies, for pooled and concerted investigations, indeed, for the orchestration of all relevant disciplines and professional practices.”

Frank contributed to making a niche of such a broad field in the federal government by starting the intramural gerontology program in the NIH. After he met NIH director Lewis Thompson in 1940, the NIH decided to create the Unit on Gerontology through the Macy Foundation’s short-term grant.²⁹ With the expiry of the grant in 1941, the NIH began to support the unit as a part of its regular institutions, as the federal government recognized the importance of the social and medical problems incurred with the aging population in the country.³⁰ The NIH’s intramural gerontology program kept growing thereafter amid the steadily increasing government budget for science and the persistent controversies on the federal government’s role in promoting Americans’ health (Strickland, 1972, pp. 154–157; Harden, 1986, p. 182).

Nathan Shock, who directed this program for more than thirty years at the gerontology laboratory located in the Baltimore City Hospitals

²⁹ Frank to Thompson, 11 March 1940, Record Group 443 at the National Archives and Records Administration, College Park, Maryland [hereafter NARA-RG443], Records of NIH 1930-1948, Individual Institutes (Org. File) Chemistry—Phys Biology National Heart Institute, Box 135, Folder 0110; Thompson to Frank, 12 March 1940, NARA-RG443, Records of NIH 1930-1948, Individual Institutes (Org. File) Chemistry—Phys Biology National Heart Institute, Box 135, Folder 0110; Thompson to Karl Meyer, 1 May 1940, NARA-RG443, Records of NIH 1930-1948, Individual Institutes (Org. File) Chemistry—Phys Biology National Heart Institute, Box 135, Folder 0110.

³⁰ “Opening Remarks of Surgeon General Thomas Parran,” 23 May 1941, NWS, Box 11, Folder E. J. Stieglitz Conference on Mental Health 1941, p. 2. Also see Harden (1986, pp. 179–180).

(BCH), was another key figure representing the career transition from the science of growth to gerontology, as I have already mentioned. Upon completing his graduate education in 1930 at the University of Chicago under A. Baird Hastings, Anton Carlson, and L. L. Thurstone, Shock investigated the changing physiological parameters of children using the longitudinal method in the Institute of Child Welfare Research at the University of California. Noteworthy is that this research was funded by the LSRM and the Macy Foundation, especially through Lawrence Frank.³¹ Yet Shock's research focus migrated to the other end of life through the very people who led him to investigate the early periods. In fact, two of his graduate advisors – Hastings and Carlson – joined the Club for Research on Ageing and participated in the early development of the field, while Frank administered the gerontology program at the Macy Foundation. Notably, Frank and Hastings recommended Shock as new chief of the Gerontology Unit, when the first chief, Edward Stieglitz, resigned for a personal reason in 1941.³²

In many respects, Shock's early aging research at the unit was structured around the methods used in his past investigations of children and adolescents at Berkeley and Chicago. Above all, his study of senescence during the 1940s often relied on laboratory approaches and instruments that he had already employed in tracing the physiological alteration of the young subjects in the previous decade.³³ For instance, using the elderly institutionalized at the BCH, Shock measured the changes of the acid–base balance in the blood, a phenomenon he had examined with the California children in the 1930s. After disturbing the balance in the blood with chemical means, he measured the time for the blood to return to its initial state, which revealed a physiological difference between the growing and aging bodies.

For Shock, the relationship between growth and aging was highly important in gerontology, as he discussed many times in his publications. In *Trends in Gerontology*, for example, he wrote that “growth, development, and maturation are...a part of the aging process just as much as are atrophy and degeneration” (Shock, 1951a, p. 1). He also mentioned Minot's claim that “the rate of change is greatest in the fetus,

³¹ Frank to Robert Underhill, 10 January 1940, NWS, Box 2, Folder U of C correspondence K-Z; “NIA Interview Transcript,” NWS, Box 1, Folder Biography, p. 13.

³² On Stieglitz's resignation, see Frank to McCay, 26 September 1953, NWS, Box 30, Folder Macy Foundation Contribution. On Shock's appointment, see Sebrell to Shock, 23 May 1941, NWS, Box 1, Folder Career Appointments; Hastings to Shock, 5 June 1941, NWS, Box 1, Folder Career Appointments.

³³ Shock to “Tommy,” 30 May 1944, NWS, Box 7, Folder Correspondence 1934–1974.

less in the infant....and after maturity it is usually so slow that it can be measured only by widely spaced observations.” This broad definition of aging accompanied a wide range of disciplines and topics in gerontology. When the members in the multidisciplinary field came from animal husbandry, embryology, child psychology, and cardiology, the subjects in the science of senescence embraced animal nutrition, embryogenesis, psychological adaptation, and chronic heart diseases in old age.

Such a widely delineated scope of fields and subjects in gerontology prompted an increasing number of scientists to contribute to studies of growth and aging, as could be seen in Shock’s *A Classified Bibliography of Gerontology and Geriatrics* (1951). This book, which aimed to provide a comprehensive register of the current literature in the science of senescence, had a section on “regeneration and growth” that listed a total of thirty-one papers regarding growth with respect to senescence, including the works by Alexis Carrel and John Saxton (Shock, 1951b). In the first supplement published in 1957, this section had twenty-four additional papers, such as Alfred Cohn’s article on chicken embryos and Henry Simms’s paper on tissue culture (Shock, 1957, pp. 17–18). In the next supplement, the section vastly expanded with a modified title, “Regeneration and Growth (cell death)” (Shock, 1963, pp. 22–24). This section, covering the literature from 1956 to 1961, had forty-seven papers along with twenty-three related articles, including those regarding a new subject, cell death.

The NIH supported many of the scientists mentioned in this bibliography. Clive McCay’s research on caloric restriction was just one of the projects on aging and growth funded by the NIH. Sponsored projects included a study of the impact of ionizing radiation on cell growth and aging, together with an investigation of the influence of growth-inhibiting vitamins and hormones upon senescence.³⁴ Psychological research on adjustment in old age with respect to the experience in early life was also supported mainly through the National Institute of Mental Health’s aging research program headed by Shock’s colleague, James Birren (Hunt and Mohler, 1958, p. 34; Birren, 2004).

Of course, Shock’s own research was also funded by the NIH as one of its intramural projects. In particular, the Baltimore Longitudinal Study of Aging (BLSA) that Shock started in 1958 was a good example of a correspondence between growth research and gerontology, as it followed his previous methodology for tracing the physiological

³⁴ “Research on Geriatrics and Gerontology,” 24 February 1954, NARA-RG443, UD/067/Entry1, Central Files, Office of Director NIH FRC 156, Box 102 of 159, Folder RES 9-11 National Institute of Aging (NIA)/Gerontology (NIH), 1951-1956, p. 3.

alteration in California children. By inviting volunteers in Baltimore and other cities to visit Shock's laboratory in a regular interval, he was able to track the changes in each participant's physiological parameters such as basal pulse rate and neuromuscular function, which may not necessarily follow chronological age. Although the BLSA started with only one volunteer in 1958, it quickly grew into a longest-running research project in gerontology with an increasing number of volunteers, who hoped to contribute to the advancement of science by becoming human subjects (Lederer, 1995, p. 128).

The BLSA represents how gerontologists appropriated the agenda of the child study movement as well as its methodology. As Shock implemented Frank's social vision of well-coordinated childhood in his longitudinal study of children funded by the LSRM and the Macy Foundation, the BLSA aimed at drawing a picture of normal aging undisturbed by negative social and medical factors such as poverty and illness that might distort the normal pathway of senescence (Moreira and Palladino, 2008). Indeed, Shock's previous subjects in his human aging research were the impoverished and chronically ill seniors institutionalized at the BCH, which was still playing its past role as a public asylum-hospital for the city's marginalized population (Carroll, 1966; Rosenberg, 1987, pp. 322–327). To Shock and his colleagues, his use of such people posed a significant problem, because their misspent youth due to poverty and wrong self-management made their aging process deviate from the "normal" pathway.³⁵ Instead, he turned to the "great majority of the aged who lived normal lives in their own communities" and enthusiastically volunteered in his project as human subjects.³⁶ By studying these participants, he thought that he followed a desirable course of human development leading to active elderly citizens with a sound mind and body, just as his early work on children was expected to help reveal a pathway toward normal and healthy adults.

Who, then, were "the great majority of the aged who lived normal lives"? This question highlights Shock and his associates' longstanding preference for middle-class Americans as human subjects, because they were supposed to stay in the most normal route of human development. What the American middle class ideologically represented, namely, the socially responsible and economically active citizenship, guided Shock

³⁵ Memorandum, 30 August 1949, NWS, Box 30, Folder Club for Aging, Box 30, p. 4; "The Aging Program of the National Institutes of Health," 30 July 1959, NWS, Box 22, Folder Longitudinal Study Administrative Record 1956–1962, p. 2.

³⁶ "The Aging Program of the National Institutes of Health," 30 July 1959, NWS, Box 22, Folder Longitudinal Study Administrative Record 1956–1962, p. 2.

and his colleagues' preference on research participants in their longitudinal studies, whose ultimate goal was to create the very citizens. In effect, after Shock conducted his California research using children recruited from middle-class families, he heard Frank's objection to "the use of institutional population" in the prospective study of aging during a 1941 gerontology conference.³⁷ As the California study had illuminated the desired course of growth and development that could be seen among children from well-off families, gerontological research had to depend on healthy middle-class adult volunteers. In 1958, Shock actually carried out this idea by implementing the BLSA, which would enable gerontologists to "make recommendation" that could help one avoid "disabilities in old age" and make life "more effective and meaningful."³⁸

A more articulate vision behind Shock's work could be found in the writings of Frank, a sponsor and close professional colleague of Shock's. As Dennis Bryson has argued, Frank did not want violent political actions such as strike and revolution to determine the course of social evolution, and instead focused on managing each individual's personality, which should continue to develop even after adulthood (Bryson, 1998). Frank stated that "maturity is not a fixed state or condition which we automatically reach at twenty-one; it is an ongoing process of continual readjustment" (Frank, 1947, p. 321). Unfortunately, there were some elderly people whose personality was still shaped by childhood memory of "coercive experiences, of humiliation, of resentments, of bitterness and acerbity, [and] of [fantastic] hopes." Furthermore, some seniors were highly rigid and reactionary, since they were opposing "even the most urgently needed alterations, some of which would work to their own personal benefit." In this state, it was tragic that "the conflicts and upheavals, domestic and international, the uprisings and revolutionary movements, arise in large part from the very rigidity, the loyalty to archaic and anachronistic beliefs and institutions which are blocking the path to a more humanly desirable way of life." Gerontologists' job was thus crucial. By overcoming widespread pessimism and defeatist attitude toward old age, the scientific experts had to "wake up" and "reorient" these conservative seniors who were still living in the world of their disagreeable childhood. This was a way

³⁷ Smuts, 2006, p. 158; "Conference on Nutritional Requirements for the Ageing Population," 1–2 November 1941, NWS, Box 30, Folder Conference on Nutrition, NWS, p. 10.

³⁸ Shock, "The Gerontology Branch," NWS, Box 21, Folder Longitudinal Study W. W. Peter 1957–1958 June.

to “renew our culture and achieve some kind of humanly decent social order and world order.”

This view signaled the coming of an age when senescence, along with childhood, was increasingly becoming a subject of scientific scrutiny and control. After child growth became a target of multidisciplinary experts’ observation and intervention in the 1920s, old age also emerged as a focal point of scientific attention and management from the 1930s. In this process, gerontologists who had studied growth brought their former socio-cultural perspective to the novel field to form the new agenda, which was to promote a positive outlook on old age and make physically and mentally sound seniors well-adjusted to modern capitalist society. Indeed, this effort by gerontologists was seen in many venues – such as their creation of “Old Age Counseling Center” for offering scientific advice for the elderly, participation in the White House Conference on Aging as an expert panel, and popular articles on the danger of overeating and high-calorie diets that would make their later years unhappy.³⁹ As several historians and sociologists have pointed out, however, this entailed a coercive framing of seniors’ lifestyle (Ballenger, 2006; Cole, 1992; Katz, 2005). While taking care of one’s health, activity levels, and social and psychological adaptation was highly valued and strongly recommended by gerontologists, other pursuits, such as political consciousness and deeper introspection, might not be encouraged. In this sense, some scholars say that the elderly of the twentieth century were treated like children, as both were placed under experts’ surveillance and professional gaze (Hockey and James, 1993).

Conclusion

Apart from the events described above, there was another line of development in medicine and biology which became steadily important over the past years. As early as the 1930s, several British epidemiologists observed that health in early life substantially influenced the mortality in later life (Kermack et al., 1934). Their statistical analysis of the population after 1850 showed that as the mortality of infants and children was gradually lowered over time due to improving nutrition and environment, their enhancing health was carried through their later life. Significantly, this work was accompanied by an associated line of research on early life by Charles Stockard and others, especially that on

³⁹ See, for example, McCay, 1943; Lawton to Cowdry, 11 November 1946, Box 42, Folder 5, EVC; Achenbaum, 1995, pp. 187–208.

the “critical period,” a moment in development that was the most sensitive to environmental variations and would determine the later course of growth and maturity (Stockard, 1921; Pauly, 1996; Kuh and Davey-Smith, 1993, pp. 110–111). In the 1970s, these topics were explored more systematically with new etiological and epidemiological studies of several chronic diseases, which indicated that the circumstances of the fetal phase and the following early stages would heavily influence the chance of the outbreak of several chronic maladies in advancing years, such as heart diseases, cancer, diabetes, stroke, and depression. Research on this subject, the developmental origins of health and disease, has recently arisen as an active scientific arena (Gluckman et al., 2010).

This new interest, along with gerontologists’ efforts that I have described so far, constitute how we come to view our life course in a novel manner, since early and later life that was long held separate has been shown to have multiple connections. The death of tissues which was thought to occur in senile body is found to take place even during embryogenesis. Cardiovascular diseases whose causes might be identified in adulthood lifestyle may also hold a deeper origin associated with the experiences during the infantile or intrauterine phases. Even the rate of aging itself, together with longevity, can be considerably influenced by the number of dietary calories taken during the stages of growth. In such a state, Minot’s paradoxical claim that aging occurred at the highest rate in early life may still be considered right in a sense. It is thus no wonder that for the investigation of both ends of life the same practical and theoretical apparatus could be used, borrowing the concept of physiological – rather than chronological – age.

What, then, has become the general perception of growth and senescence? Admittedly, the old metaphor of the ascending and descending staircase has persisted. It is also significant that each period in life – infancy, childhood, adolescence, adulthood, middle age, and old age – has come to be closely associated with certain cultural expectations, administrative processes, and healthcare provisions that were deemed fit in the modern world (Chudacoff, 1989). But it should be noted that the word, aging, has taken over a wider signification with a new politico-cultural twist. In effect, with the popularity of professional sports such as gymnastics, it has become known that physiological decline takes place even among teens trained as athletes. It is also appreciated that children’s ability to learn foreign languages declines quite rapidly during their growth. Unsurprisingly, our concern about such declines emerged under the backdrop of the complex and

competitive modern society and the heightening demands for control over our life course. In preparation for their future in this society, children need to be controlled during their education in accordance with their decreasing capacity of learning. Seniors' lifestyle should also be controlled for their better adaptation to an increasingly complex capitalist world. Although the traditional imagery of a life-pathway from youth to old age is still taken for granted, this shows that aging has come to assume a broader meaning associated with a need for control within the cultural, economic, and institutional matrix of contemporary society. As some scholars have put it, such changes may imply the advent of "ageless" society and the emergence of a postmodern life course (Katz, 2005; Turner, 1994; Featherstone and Hepwood, 1991).

The launching of a new journal in 1972, *Mechanisms of Ageing and Development*, was perhaps the biomedical community's delayed response to this intricate matter. According to Bernard Strehler, the founding editor and Shock's close colleague, the relationship between growth and aging was one of the most interesting topics. A new journal was necessary to forge an arena in which investigators of development and senescence could publish their latest discoveries on their overlapping subjects. With *Mechanisms of Ageing and Development*, therefore, gerontologists and scientists of growth could expect that the "points of inter-relevance will become [focused] and that this in turn contribute to more rapid advances in basic understanding in both fields" (Strehler, 1972, p. 1). The study of aging and growth found its niche in this new journal, as it was placed within the novel research programs, research organizations, and cultural discourses.

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