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Measuring senescence in human populations

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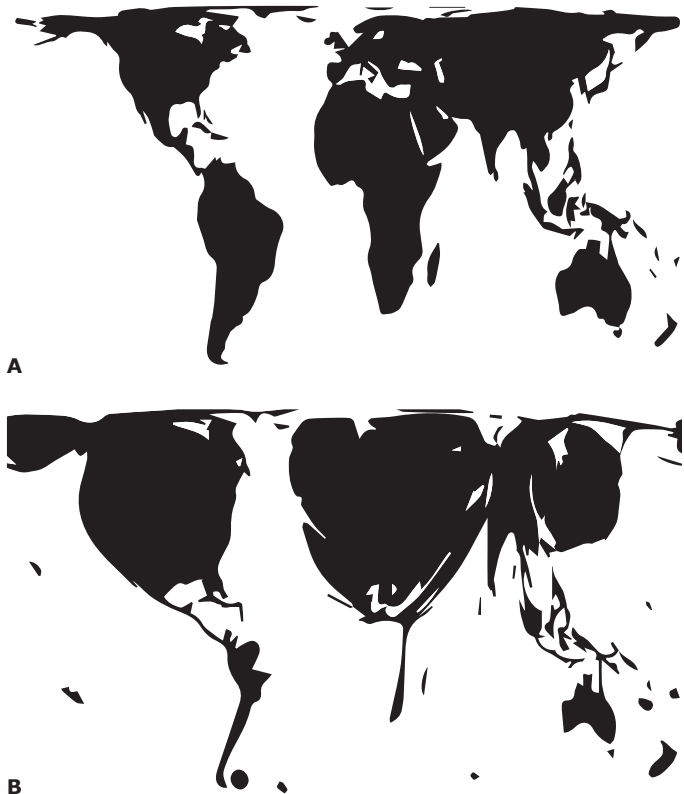
INTRODUCTION TO PART II

Senescence from a global perspective

As a result of senescence, the risks of dysfunction and disease in human populations increase with chronological age. With vast amounts of empirical data and theoretical knowledge, the senescence process has been characterised extensively in western populations. Here, senescence is well known to be predominantly marked by cardiovascular disease, diabetes mellitus, and cancer.¹⁻³

By contrast, as illustrated in Figure 6.1, very little research is performed on senescence in non-western populations, such as in Africa.⁴⁻⁹ The course of senescence and its relation with disease in these populations remains obscure. Meanwhile, the study of senescence in these populations is valuable for both western and non-western populations. It can unveil new causes of senescence-related diseases, facilitate the investigation of their possible causes that are rare or ubiquitous in western populations, enable the unravelling of the link between infectious diseases and senescence-related diseases, and support the design of local research agendas and public health policies to combat these diseases.^{4-6,8}

Figure 6.1 • Research is almost exclusively performed in western populations. On map A, each country is displayed according to its actual size. On map B, each country is drawn such that its size reflects the number of scientific articles published in 2001 by authors resident in that country relative to the size of its total population. The maps were obtained from Worldmapper and adjusted by B.W. Florijn. Copyright of the Sasi Group at the University of Sheffield and Mark Newman at the University of Michigan. Reproduced with permission.¹⁰



Senescence from an environmental perspective

Next to age, lifestyle is the most important risk factor of the diseases that are related to senescence in western populations.¹¹⁻¹⁵ A western lifestyle is affluent and sedentary. Industrialisation, technological innovation, urbanisation, and economic growth have allowed foods to become abundantly available and enriched with energy and at the same time have greatly reduced the need for exercise in daily life.¹⁶⁻¹⁹ It has been established that a western lifestyle interferes with the body's physiology, for example by causing inflammation, and that it leads to obesity, dyslipidaemia, hypertension, cardiovascular disease, diabetes mellitus, and cancer.^{12,20}

Where the aforementioned advancements have not yet taken place, food supply depends on the harvest and climate, hunger is frequent, and physical exertion is indispensable for subsistence. To know how the inhabitants of such regions senesce means to know whether the diseases that are related to senescence in western countries arise largely independent of a western lifestyle or rather as its consequences.

Improvements in hygiene and public health have restrained infectious diseases in western populations, whereas in non-western populations infectious diseases are the main cause of disease and death. In those regions where a western lifestyle is currently emerging, it coexists with local traditional non-western lifestyles. As a consequence, an expansion of obesity, cardiovascular disease, and diabetes mellitus is

accompanied by the persistence of malnutrition and infectious diseases. This is referred to as the double burden of disease. While infections induce inflammation, the diseases that are related to senescence in western populations also have an inflammatory nature. It is postulated, therefore, that frequent exposure to infections excites these diseases,²¹⁻²⁴ but, unfortunately, studies on this postulation have seldom been conducted in populations without a western lifestyle.

Senescence from an evolutionary perspective

The history of modern human populations dates back to about 250 000 years ago and those of their hominin predecessors millions of years more. During most of human history, survival was severely comprised by malnutrition and infectious diseases. Only since a few decades and only in western populations, these threats have been largely overcome. These harsh environmental demands have exerted strong selective pressures through many generations. These pressures have promoted qualities that matched the environment, in particular thrifty and proinflammatory qualities.^{25,26} Thriftiness refers to the metabolic efficiency to ingest, process, and store nutrients. An immune system is proinflammatory when it aggressively fights pathogens and other potentially injurious agents.

The thrifty and proinflammatory qualities that have been promoted during human evolution are in mismatch with the envi-

ronment in modern western populations. When food is abundant, physical activity is needless, and infectious diseases are uncommon, thriftiness and inflammation lead to obesity, dyslipidæmia, hypertension, cardiovascular disease, diabetes mellitus, and cancer. From this point of view, the diseases that arise during senescence in western populations are, at least partly, attributable to conflicts between out-dated genes in a brand-new environment.^{16,20,22,25-27}

In non-western populations where the present environment resembles the harsh environments in which humans have evolved, the selective pressures in the past environments match more closely with those in the present environments. The thrifty and proinflammatory qualities that have long been promoted are still needed for survival in these populations. If the diseases related to senescence in western populations are attributed to a mismatch between genes and the environment, it is expected that these diseases arise less frequently during senescence in non-western populations. However, it has only infrequently been studied whether the thrifty and proinflammatory qualities cause diseases during senescence in non-western as in western populations.

Measuring senescence through morbidity in a traditional African population

With an eye to the three preceding perspectives, we have studied senescence in a traditional rural African population without a western lifestyle in one of the least

developed regions of Ghana. Previously, this population has been characterised extensively with regard to its age patterns of mortality and fertility, its lifestyle and culture, the presence of infectious diseases, and the genetic and physiological determinants of inflammation.²⁸⁻³⁴

An impression of the lifestyle, culture, and environment of the Ghanaian study population is given by the pictures on the following pages.

In this population, we have measured senescence through morbidity, focussing on handgrip strength and cardiovascular disease. Loss of handgrip strength is a widely used measure of senescence.³⁵⁻³⁹ Cardiovascular disease is the most prevalent disease related to senescence in western populations.⁴⁰⁻⁴² As described in more detail in the following chapters, we have assessed the age patterns of handgrip strength and various cardiovascular disease, the presence of their determinants, and their relations to mortality in older inhabitants.

By studying senescence in this traditional African population without a western lifestyle, we aim to clarify whether the diseases related to senescence in western populations arise largely independent of such a lifestyle, as is suggested when senescence is regarded as a process intrinsic to the human body, or are rather consequences of such a lifestyle. If a decrease in handgrip strength and an increase in cardiovascular disease are observed in this population similarly to western populations, a western lifestyle is not a prerequisite for their occurrence during senescence, inflammation

due to infections may be an alternative cause, and a mismatch between genes and the western environment does not satisfy as an evolutionary explanation of the senescence process. If a decrease in handgrip strength and an increase in cardiovascular disease are absent in this population as opposed to western populations, a western

lifestyle is a prerequisite for their occurrence during senescence, inflammation due to infections cannot by itself be a sufficient cause, and a mismatch between genes and the western environment is reinforced as an evolutionary explanation of the senescence process.



Figure 6.2 • Signboard at the office in the Ghanaian research area. By courtesy of A.D. Pieterse. Reproduced with permission.



Figure 6.3 • A typical compound household in the Ghanaian research area. By courtesy of D. van Bodegom. Reproduced with permission.



Figure 6.4 • Clothes and grains being dried in a courtyard in the Ghanaian research area. By courtesy of H. Sanchez-Faddeev. Reproduced with permission.



Figure 6.5 • Transportation across a river in the Ghanaian research area. By courtesy of D. van Bodegom. Reproduced with permission.



Figure 6.6 • A borehole well in the Ghanaian research area. By courtesy of L. May. Reproduced with permission.



Figure 6.7 • Milling of grain in the Ghanaian research area. By courtesy of D. van Bodegom. Reproduced with permission.



Figure 6.8 • A household's kitchen and, in the background, a field of grain in the Ghanaian research area. By courtesy of T. Menger. Reproduced with permission.



Figure 6.9 • A herd of cattle being led through the town of Garu near the Ghanaian research area. By courtesy of A.D. Pieterse. Reproduced with permission.



Figure 6.10 • A herd of cattle being grazed in the Ghanaian research area. By courtesy of L. May. Reproduced with permission.



Figure 6.11 • A market in the Ghanaian research area. By courtesy of D. van Bodegom. Reproduced with permission.



Figure 6.12 • Different foods sold at a market in the Ghanaian research area. By courtesy of H. Sanchez-Faddeev. Reproduced with permission.



Figure 6.13 • Children washing in a tropical rain shower in the Ghanaian research area. By courtesy of T. Egberts. Reproduced with permission.



Figure 6.14 • A brewery of pito beer in the Ghanaian research area. By courtesy of T. Egberts. Reproduced with permission.



Figure 6.15 • A health care clinic in the Ghanaian research area. By courtesy of T. Egberts. Reproduced with permission.

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