

The background of the cover features a repeating pattern of stylized, light green leaf motifs. Each motif consists of a short stem with two leaves, one slightly larger than the other, arranged in a V-shape. These motifs are scattered across the entire cover, with some appearing larger and more prominent than others.

GROWING YOUNG

Second Edition

Ashley Montagu

 ***Greenwood***
PUBLISHING GROUP

GROWING YOUNG

In our innermost soul we are children and remain so for the rest of our lives.

—SIGMUND FREUD

Our whole life is but a greater and longer childhood.

—BENJAMIN FRANKLIN

This page intentionally left blank

GROWING YOUNG

Second Edition

ASHLEY MONTAGU

BERGIN & GARVEY PUBLISHERS
NEW YORK • WESTPORT, CONNECTICUT • LONDON

Library of Congress Cataloging-in-Publication Data

Montagu, Ashley, 1905-
Growing young / Ashley Montagu.—2nd ed.

p. cm.

Bibliography: p.

Includes index.

ISBN 0-89789-167-8 (alk. paper)

ISBN 0-89789-166-X (pbk. : alk. paper)

1. Maturation (Psychology) 2. Child development. 3. Aging—Psychological aspects. 4. Youthfulness. I. Title.

BF710.M65 1989

155—dc19 88-27610

Copyright © 1981, 1989 by Ashley Montagu

All rights reserved. No portion of this book may be reproduced, by any process or technique, without the express written consent of the publisher.

Library of Congress Catalog Card Number: 88-27610

ISBN: 0-89789-167-8 (hardcover)

ISBN: 0-89789-166-X (pbk.)

First published in 1981

Bergin & Garvey Publishers, One Madison Avenue, New York, NY 10010
A division of Greenwood Press, Inc.

Printed in the United States of America

10 9 8 7 6 5 4 3 2

To Helen and Preston Tuttle

This page intentionally left blank

Contents

Preface to the Second Edition ix

Preface to the First Edition x

Communication from a Flying Saucer xi

Chapter 1 · Introduction 1

Chapter 2 · Neoteny and Human Biological Evolution 12

Chapter 3 · The Evolution of Human Behavior 46

Chapter 4 · Advantages of Immaturity: A Womb with a View 62

Chapter 5 · The Child 94

Chapter 6 · The Neotenuous Traits of the Child 106

Chapter 7 · Those Whom the Gods Love 172

Chapter 8 · Import 198

Appendix: The History of Neoteny 207

Glossary 247

Tables 254

Figures 260

References 273

Index 287

Tables	<i>Table 1. Neotenous Structural Traits in which Mongoloids and Negroids Differ from Caucasoids</i>	254
	<i>Table 2. Comparison of Male and Female Neotenous Traits</i>	255
	<i>Table 3. Neotenous Physical Traits in Humans</i>	255
	<i>Table 4. Neotenous Functional Traits in Humans</i>	256
	<i>Table 5. Growth of the Human Brain</i>	257
	<i>Table 6. The Basic Vital Sequences</i>	258
	<i>Table 7. Relation of Cell Number in Cortical Sections with Age</i>	259

Figures	<i>Figure 1. Gerontomorphic Skull Development in Monkeys and Apes</i>	260
	<i>Figure 2. Neoteny of the Human Skull</i>	261
	<i>Figure 3. Midsection Outlines of Newborn and Adult Skulls</i>	262
	<i>Figure 4. Comparison of Newborn and Adult Ape Skulls</i>	262
	<i>Figure 5. Comparison of Juvenile and Adult Chimpanzees</i>	263
	<i>Figure 6. Skull of Australopithecus africanus</i>	264
	<i>Figure 7. Comparison of Primate Skulls</i>	265
	<i>Figure 8. Suggested Common Primate Stem</i>	266
	<i>Figure 9. The Cranial Flexure</i>	267
	<i>Figure 10. Human Adult Skull</i>	268
	<i>Figure 11. Appealing Neotenous Features</i>	269
	<i>Figure 12. The Palatine Portion of the Premaxilla</i>	270
	<i>Figure 13. Evolution of the Lumbosacral Angle in Monkeys, Apes, and Humans</i>	271
	<i>Figure 14. Pedomorphosis in the Evolution of Humans</i>	272

PREFACE TO THE SECOND EDITION

No author could have been more pleased by the critical reception given his book than I was following the publication of *Growing Young* in 1981. There were several exceptions (as was to be expected), conforming to the classical description of "exceptional" critics, as the kind who walk down the field after the battle and shoot the wounded. But even from the deviant behavior of such critics one may learn, just as one may learn from deviants generally what a society should be, by their being what society isn't.

What has pleased me most has been Stephen Jay Gould's judgment of the book as "the best statement ever written on the most important, neglected theme of human life and evolution."

In the eight years that have elapsed since the appearance of the book, I have been steadily at work to keep it up-to-date and to clarify the discussion wherever that was indicated. I have also added some new findings.

Perhaps it needs to be restated here that the book deals with essentially novel ideas concerning fundamental matters relating to the growth and development of physically and mentally healthy humans. It questions age-old beliefs and offers scientifically based discoveries for a wholly new conception of the child. It provides a new understanding of the nature of human nature, that we are designed always to remain in a state of development. It discusses the unique manner in which humans have evolved physically and in this way prepares the reader for the understanding of the mechanism by which humans have evolved behaviorally, in both cases by a process called neoteny, a term which will be fully explained in the pages which follow.

I hope the reader will find the book enlightening as well as reassuring, for its ideas have a big message to convey: our genes carry good news.

I have again to thank the librarians of Princeton University and the Medical Center at Princeton. I am also most grateful to Dr. Julia Gordon for her careful reading of the galleys.

Princeton, N.J.

PREFACE TO THE FIRST EDITION

*Sometimes one has to say difficult things,
But one has to say them as simply as possible.*

—G. H. HARDY

This book represents the result of a great many years of work and study in a large variety of seemingly unrelated fields, all, however, in my view bearing upon the better understanding of the nature of human nature and the consequences of that understanding for the healthy development of the person and of humanity. It is essentially a book of discovery, really an adventure story, but one which is solidly based in the research findings of innumerable scientists and thinkers. The ideas presented in this book should be part of the mental equipment of everyone. But that the reader will be able to decide for himself.

Here I should like to thank the many kind friends who read the manuscript and gave me much help in making this a better book than it would otherwise have been. These are Weston La Barre, emeritus professor of anthropology at Duke University, Dr. Robert Butler, director of the National Institute of Aging, Dr. Thomas J. Cottle, Harvard University Medical School, Dr. Judith Economos, Ms. Renate Fernandez, Ms. Suzanne Fremon, Drs. Phillip and Julia Gordon, Professor Roderic Gorney, Department of Psychiatry, UCLA, Professor Stephen Jay Gould, Museum of Comparative Zoology, Harvard University, Dr. Judith Lynne Hanna, University of Maryland, Professor Floyd Matson, Department of American Studies, University of Hawaii, and Mr. Preston Tuttle.

For their many courtesies I thank Helen Zimmerberg, Louise Schaeffer, and Elizabeth Hynes of the Biology Library, Terry Caton, Janice Welburn, Pat Swift, and Mary Chaikin, of the Psychology Library at Princeton University, also Louise Yorke of the library at the Princeton Medical Center. Finally, to Gladys Justin Carr and Leslie Meredith at McGraw-Hill, for their editorial good office, many thanks.

Princeton, N.J.

COMMUNICATION FROM A FLYING SAUCER

The trouble with earthlings is their early adulthood. As long as they are young, they are lovable, open-hearted, tolerant, eager to learn and to collaborate. They can even be induced to play with one another. Most adults, however, are mortal enemies. The only educational problem earth has is how to keep them young.

For life, evolution, progress, and adaptation to new situations they are useful only as long as they keep their youthful qualities. But the funny thing is that in all the educational institutions I visited the object was to hasten maturity instead of delaying it. Surely your history can teach you that only the races with the longest childhood were able to remain in the cultural mainstream. The ideal should be to prolong childhood up to sixty years. Then you would be able to produce a real planetary culture.

Once you realize the importance of this prolongation it will be easy for your biologists to work out the necessary techniques to keep your children teachable. Your cultural life has already become too rich, too complicated, for you to content yourselves with an educational period of a mere twelve years. True specialization should start at sixty.

Compare the growth of intelligence in human children of, let us say, seven to fourteen, with that of children of fourteen to twenty-one. Do you see the dramatic slowdown the moment maturity appears? Many children simply stop at sixteen, some even at fourteen. And even those who go on evolving usually progress along lines already laid down at the age of ten or twelve. No new regions of mind normally open in human beings after that.

The most shocking fact about evolution is not that we descend from something we probably wouldn't like to meet alone in a forest at night, but that something descends from us which we certainly wouldn't like to meet even at noon in a crowded street. Perhaps the subhuman is more acceptable than the suprahuman.

*Equals One, 1969-2, The Journal of Auroville, Pondicherry-2, India**

*Many readers have assumed that the above was written by the author of this book. It was not. The source of this remarkable *aperçu* is as stated above.

This page intentionally left blank

CHAPTER 1

Introduction

Childhood is the name of the world's immediate future; of such, and such alone, is the promise of the kingdom of man.

—WALTER DE LA MARE

Man's capacities have never been measured; nor are we to judge of what he can do by any precedent, so little has been tried.

—HENRY DAVID THOREAU

Growing young, the title and the subject of this book, is a process which has played a fundamental role in the evolution of the human species and in the development of every human being who has ever lived. Moreover, its significance and its ramifications for the future of each of us and of humanity in general are so staggering that an understanding of it should be a part of the mental equipment of everyone. Yet, as a scientific principle, it is known only to a few scientists; others—the vast numbers of human beings whose lives might be changed by the application of this principle—are ignorant of it. To fill that void, to explain the meaning of “growing young,” is the purpose of this book.

The process of growing young is known as NEOTENY or PEDOMORPHISM. These terms, which will be explained in detail in the following pages and in the Appendix, refer to the retention into adult life of those human traits associated with childhood, with fetuses, and even with the fetal and youthful traits of our own species. Neoteny includes the slowing down of the rate of development and the extension of the phases of development from birth to old age.

This is a concept that is not easy to understand. We see evidence before us all the time that adults are different from children, and we think we know that an adult human being is nothing like the FETUS curled up in its mother's womb. Furthermore, we tend to believe that this is the way things should be: grown-ups and children are two separate classes of beings, and because adults possess the power and

the strength, we spend the years of our childhood yearning to be grown up. Many of us in our youth falsified our age in an effort to seem older than we really were. And as we approached the end of schooling and the beginning of what we were taught was "real" life, we rejoiced that we were finally becoming adults and different from children.

Yet the truth about the human species is that in body, spirit, feeling, and conduct we are designed to grow and develop in ways that emphasize rather than minimize childlike traits. We are intended to remain in many ways childlike; we were never intended to grow "up" into the kind of adults most of us have become.

It is the purpose of this book to show how the principle of neoteny has affected first our physical evolution and DEVELOPMENT and then the evolution of our behavior. Finally, we will see that the role neoteny is designed to play in our social development is of fundamental significance. We will realize that the marked retention of juvenile physical traits is one of the major characteristics that differentiates human beings from other animals. When this process is carried over from physical traits to behavioral patterns, human beings can revolutionize their lives and become for the first time, perhaps, the kinds of creatures their heritage has prepared them to be—youthful all the days of their lives.

What, precisely, are those traits of childhood behavior that are so valuable and that tend to disappear gradually as human beings grow older? We have only to watch children to see them clearly displayed: curiosity is one of the most important; imaginativeness; playfulness; open-mindedness; willingness to experiment; flexibility; humor; energy; receptiveness to new ideas; honesty; eagerness to learn; and perhaps the most pervasive and the most valuable of all, the need to love. All normal children, unless they have been corrupted by their elders, show these qualities all day every day of their childhood years. They ask questions endlessly: "Why?" "What is it?" "What's it for?" "How does it work?" They watch, and they listen. They want to know everything about everything. They can keep themselves busy for hours with the simplest toys, endowing sticks and stones and featureless objects with personalities and histories, imagining elaborate stories about them, building sagas that continue day after day, month after month. They play games endlessly, sometimes carefully constructing the rules, sometimes developing the game as they go along. They accept changes without defensiveness. When they try

to accomplish something and fail, they are able to try to do it another way, and another, until they find a way that works. They laugh—babies learn to smile and laugh before they can even babble—and children laugh from sheer exuberance and happiness. Unless they suspect they may be punished for it, they tell the truth; they call the shots as they see them. And they soak up knowledge and information like sponges; they are learning all the time; every moment is filled with learning.

How many adults retain these qualities into middle age? Few. They tend to stop asking those questions that will elicit information. Not many adults, when confronted with something unfamiliar, ask, as children always do: "What is it?" "What's it for?" "Why?" "How does it work?" Most adults draw back from the unfamiliar, perhaps because they are reluctant to reveal ignorance, perhaps because they have become genuinely indifferent to the interesting experiences of life and consider that absorbing something new into the old patterns is simply too much trouble.

Nor can most adults content themselves with simple playthings enriched by the imagination. Witness the enormous growth of industries that cater to the "leisure-time" and "recreational" activities of adults, that manufacture the toys that grown-ups need in order to play: boats, cars, trailers, equipment for camping and hiking and running and tennis and golf, television sets, movies, sporting events, equipment for travel and even for shopping. The list seems endless. This is not to say that these activities are not enjoyable and healthful, but most of them are elaborate beyond the dreams of children. The difference, it has been said, between the men and the boys is the price of the toys. Very few adults in our affluent Western civilization are able to maintain themselves by themselves, with the help only of their imagination and their own physical energy. They need to bolster their efforts with huge amounts of expensive equipment.

Most adults have lost, too, the ability to laugh from sheer happiness; perhaps they have lost happiness itself. Adulthood as we know it brings sobriety and seriousness along with its responsibilities. Most adults have also lost the ability to tell the simple truth; many appear to have lost the ability to discern a simple truth in the complex morass they live in.

Perhaps the saddest loss of all is the gradual erosion of the eagerness to learn. Most adults stop any conscious effort to learn early in their adulthood, and thereafter never actively pursue knowledge or

understanding of the physical world we inhabit in any form. It is as though they believed that they had learned all they needed to know, and understood it all, and had found the best possible attitudes toward it, by the age of eighteen or twenty-two or whenever they stopped their formal schooling. At this time they begin to grow a shell around this pitiful store of knowledge and wisdom; from then on they vigorously resist all attempts to pierce that shell with anything new. In a world which is changing so rapidly that even the most agile minded cannot keep up with all its ramifications, the effect of this shell building on a person is to develop a dislike—even perhaps a hatred—of the unfamiliar, simply because it was not present in time to be included within the shell. This hardening of the mind—psychosclerosis—is a long distance from a child's acceptance and flexibility and open-mindedness.

In recent years in Western industrialized countries, and to some extent even in the not-so-affluent parts of the world, the cult of youth has taken over a large segment of society. It has come to be a kind of secular religion, and it has certainly given rise to (and in a circular way is also a result of) a multibillion-dollar industry. Youth is considered—by the young, at least, and a substantial number of their elders—the ideal time of life; to be young is believed to be the most desirable age of all.

It was not always thus. Through the Victorian period, and lasting until some time after World War II, in Britain and Western Europe as well as in the United States, to be old was to be revered. Governments were run by graybeards; the armies and navies were commanded by elderly generals and admirals; and rulers of empires—Emperor Franz-Joseph and Queen Victoria—were venerated not so much for their nearness to God as for their age and durability. The world's business was conducted by old men, and families were subject to the wills of their oldest members.

Young and middle-aged men in that period were considered too youthful, too inexperienced, too lacking in wisdom, too foolish, even, to take primary responsibility for important matters. And these men consulted their fathers or other older men on all significant decisions even in their personal lives; they would no more have failed to defer to these men than they would have failed to stand to attention when the National Anthem was being played.

Women suffered under this regime even more than men, because daughters were considered even more immature, more vulnerable,

and more dependent than sons and therefore in greater need of supervision and protection throughout their lives. Women who thought for themselves were rare during that period, and women who acted for themselves, without the consent of parents, guardians, husbands, or other, wiser heads, were rarer still.

The raising of children in such an atmosphere was certain to be damaging to the children. Childhood was perceived as a difficult period that was unfortunately necessary for the production of mature, no-nonsense adults, and the entire effort of the education and training of children was aimed at making adults of them as soon as possible. Thus the "ladylike" little girl and the "gentlemanly" little boy. The closer their behavior to that of adults the better. As a practical matter this meant that children were expected to demonstrate quiet good manners, respect for anyone older (hence wiser) than themselves, conscientiousness in all duties (of which there were many), willingness to study even the most uninteresting subject because it was "good for them," and an unquestioned obedience to all rules of the adult world. "It doesn't matter what you teach a boy, so long as he doesn't want to learn it," said one leading educator of the period.

Imagination was frowned upon, even feared; curiosity was derided ("Curiosity killed the cat!"); free playfulness and humor were discouraged; open-mindedness was thought to be heretical; and honesty was often considered simple rudeness. As for the most precious of all childlike qualities, the eagerness to learn, it was accepted by adults only so long as the subject of the learning was a "proper" one; otherwise it was forbidden.

Children who failed to thrive under this spartan regime were themselves blamed for their failure. It occurred to only a few people that perhaps the fault lay in the failure of the adult world to understand the nature of childhood, and in fact the failure to understand the development of human beings.

We have made some progress in this understanding over the past fifty years. Anthropologists, psychologists, other social scientists, and even some educators have begun to recognize that children are not simply small imperfect adults who must be dragooned as early as possible into the adult-behaving world. We know that children are developing human beings who will continue developing all their lives if they are not prevented. And we begin to understand that the goal of life is to die young—as late as possible!

The principle of neoteny has much to teach us concerning the

behavior of human beings, children and adults. The history of neoteny is a long one, much too long to include in its entirety at this stage of this discussion, but a brief account will help us to understand its nature and its ramifications. A more complete account is included in the Appendix.

The early work on neoteny was entirely concerned with the physical EVOLUTION and development of organisms and with the discovery that certain physical traits, characteristic of the fetus or of an immature stage of life of some specific creature, are sometimes retained into the adult stage. The term was coined in 1884 by Julius Kollmann, professor of zoology at the University of Basel, to describe the process of transformation whereby newts and similar creatures mature sexually while they are still in LARVA form.

One would hardly expect that this "discovery," which had also been made some twenty years earlier, would lead directly to a belief that human beings are programmed to retain into adulthood many of the behavioral traits that characterize human childhood. And, indeed, it was some years before the concept of neoteny was applied to human beings at all, and then only to their physical endowment. Havelock Ellis, that great liberator of the human spirit, without knowing Kollmann's work or the work of his predecessors, was the first person to apply the idea of neoteny to human beings; in 1894, he pointed out that the fetuses and young of APES and of human beings are much more alike than are the adults of the two groups. Furthermore, both are much more like adult human beings than they are like adult apes.

Louis Bolk, professor of anatomy at the University of Amsterdam, put a name to this tendency. In 1926 he pointed out that, compared with that of other primates, the rate of development of human beings from fetus through infancy and childhood into adulthood is slow and that adult human beings show many physical traits that are also features of the human fetus. This is not so true of the adults of other animals. He listed flat-facedness, minimum body hair, large brain size, structure of hands and feet, the form of the pelvis, and a number of additional physical characteristics that change in other animals but that in human beings persist into adulthood. In short, said Bolk, echoing Kollmann, "Man, in his bodily development, is a primate fetus that has become sexually mature." Bolk called this principle "fetalization." FETALIZATION was effected by retardation of the rate of development.

The importance of this slow development, or RETARDATION, was seen by J. B. S. Haldane as a major evolutionary trend in human beings. In 1932 he underscored the fact that the essential feature of the latest stage of human evolution has been not the acquisition of new features but rather the preservation of embryonic and infantile traits which had been developed when the organisms were in the womb, sheltered from violence. The retention of these features, Haldane suggested, has enabled human beings to shed much of their animalism. Haldane further proposed that if human evolution were to continue along the same lines, "it will probably involve a still greater prolongation of childhood and retardation of maturity."

Konrad Lorenz, the German ethologist, writing in 1950, maintained that by far the more important features in the investigation of human evolution are not physical but behavioral. He drew heavily on the ideas of the German sociologist Arnold Gehlen, who recognized as early as 1940 that the unique human trait is that of remaining in an unending state of development. The specialty of human beings is nonspecialization; humans have remained free to change as change is required by whatever ENVIRONMENT they encounter; they are able to develop special traits to meet special needs. Lorenz holds that these traits are behavioral as well as physical.

Physical and behavioral qualities are inextricably intertwined. The size of the brain, the agility of the limbs, posture, the structure of hands and feet, the position of eyes and ears—all make possible, or impossible, certain ways of behaving. And these features have been determined for each creature by the evolutionary process which has produced it and its kind. Therefore, before we discuss specific behavior patterns it is necessary to understand the development of physical patterns, through the evolution of the SPECIES. Only then can we understand something of the manner in which behavior potentialities evolved, even though physical and behavioral development evolved under totally different SELECTION PRESSURES. Only then will we begin to understand the biological basis of human adult behavior.

TERMINOLOGY

It has been said that definitions are not really meaningful at the beginning of an inquiry, that they can only be so at the end, but at this juncture I think we are ready for some simple definitions. Viola, in *Twelfth Night*, remarks, "Nay, that's certain: they that dally nicely

with words, may quickly make them wanton" (III:1). It is characteristic of early stages in the development of a scientific idea that those who come upon it independently usually invent their own terms to describe it. The result frequently is that such terms take on a life of their own and what was once a single specific idea assumes many different forms. This often leads to years of muddled thinking and tiresome confusion. I shall not take the reader's time by entering into a discussion of this phenomenon in connection with the idea of neoteny. Professor Stephen Gould has already ably done this in his book, *Ontogeny and Phylogeny* (1977), which has contributed greatly to the introduction of order in a backwater of science that might well have been described as awash in the systematics of confusion. Since Professor Gould and I are for the most part in agreement on these matters and on the important role neoteny has played in the evolution of humans, it may be helpful if at this point the terms that have thus far been used be clearly defined.

Pedomorphosis is the process whereby ancestral or own-species or subspecies ("races") fetal or juvenile traits are retained into later stages of individual development.

Neoteny has precisely the same meaning as pedomorphosis. The definitions usually given of both processes represent a distinction without a difference, and since this is so, the two terms will be used interchangeably in preference to fetalization, which rather narrows the concept to which these terms refer. In contrast to fetalization, neoteny and pedomorphism imply that significant evolutionary changes may occur at any developmental stage—embryonic, fetal, or juvenile—and quite possibly even later.

The only respect in which these definitions differ from those in the literature on the subject is that, to the traits of ancestors appearing in later stages of development in pedomorphism, Gould and I have added those of fetal and juvenile members of the species, so that traits appear in adult humans that are characteristic of their own fetal or juvenile species or subspecies (i.e., races). For example, as a number of independent investigators have observed, the juvenile skulls of such prehistoric HOMINIDS as the African humanlike form *Australopithecus africanus*, the *Pithecanthropine Homo erectus* (formerly known as *Pithecanthropus erectus*), and NEANDERTAL MAN exhibit many features that more closely resemble those of modern man than they do those of their own adult forms (see Fig. 14).

It has been suggested that modern humans could have come into

being from Neandertaloids by the simple retention of the juvenile traits of these forms, that is to say, by neoteny.

In this manner the neotenous forms would come to look more like grown-up juveniles than the more specialized forms from which they had evolved. These specialized forms underwent change by the additional extension and development of adult traits. For example, if the adult form had heavier eyebrow ridges, projecting jaws, and similar traits, juvenile forms would ultimately develop these as adults and might result in an even greater projection of the jaws, heavier brow ridges, and the like. This process is known as GERONTOMORPHOSIS (Gr. *geron*, old man, and *morphosis* = development of form, becoming like an old individual, meaning extreme specialization). Gerontomorphosis is a form of evolution by SPECIALIZATION of the adult stages of successive independent developments. Its net effect is to decrease ability for further evolution and to expose species to extinction.

The adults of the great apes (orangutan, chimpanzee, and gorilla) are all gerontomorphic forms (Fig. 1), as are most prehistoric men up to the Upper Pleistocene, some 30,000 years ago. Humans are born at an earlier stage of physical development than apes and as they develop remain more like immature infants than do the apes, the latter pursuing a more specialized developmental path. Human infants start off with a heavier body weight than apes and a head size which in proportion to body size is relatively the same as in the apes; but in proportion to their height, apes end up with a heavier body and proportionately smaller head. In other words, while apes diverge from what would seem to be the promise of their infant traits toward gerontomorphy, humans retain that early promise and continue to develop by stretching out their juvenility for many years. This is well brought out in Figure 2 which makes graphically clear the neoteny of the SKULL. The figure shows the growth of the chimpanzee skull (left) compared with the human skull, plotted on transformed coordinates and showing the relative displacement of parts. At the fetal stage (top) chimpanzee and human skulls are much more alike than they are at the adult stage (bottom). It will be seen that the adult human skull departs far less from the fetal form than does the chimpanzee skull at the same stage of development. Indeed, when one superimposes an outline of the human adult skull over one of a newborn human's it will be seen that the adult human skull for the most part simply represents an enlarged newborn's and is little al-

tered in proportions (Fig. 3). When one compares the growth of the newborn ape skull (in this case the orangutan) with that of the human (Fig. 4), it will readily be seen that there is a tremendous forward growth of the face and jaws and very little growth of the brainbox compared with the human. In the gorilla this kind of gerontomorphic development in the adult skull compared with its juvenile form is even more striking. Equally, if not more so, the marked extent to which the adult chimpanzee departs from the promise of its juvenile form is seen when the living juvenile chimpanzee is compared with its form as an adult (Fig. 5). From these striking photographs it is evident how closely the juvenile chimpanzee resembles both the human child *and* the adult human. From such a juvenile chimpanzee it would by neoteny require very few changes to produce a human form. Indeed, the chimpanzee, and, especially, a form resembling the pygmy chimpanzee of Zaire, in equatorial Africa, increasingly seems likely as a possible ancestor of the earliest humanlike forms. Dr. Adrienne Zihlmann and her colleagues, of the Department of Anthropology at the University of California in Santa Cruz, who have carefully studied the rare skeletal remains of the pygmy chimpanzee (*Pan paniscus*), as well as the characteristics of living members of the species, find that they move as easily on the ground as they do in the trees. In captivity they seem to walk upright more often than the common chimpanzee. In addition they are more generalized than other apes in their morphological traits, not having developed their long arms for hanging and swinging. Also, their canine teeth, brain size, and body size show fewer differences between the sexes than is the case in the other apes. In these respects pygmy chimps more closely approach humans than they do other apes.

In their chromosomal structure humans and chimpanzees are remarkably alike. The genetic changes accounting for the morphological differences between humans and chimpanzees may be quite small. A few regulatory genes, through enzymatic processes, may have large SOMATIC effects, whereas the remaining structural genes may be time dependent in their rate of fixation and of little selective significance. Hence, neoteny would not have much work to do in order to transform an ape into a human. Nevertheless, in spite of their genetic resemblance to humans, chimpanzees remain closer in form and behavior to apes than to humans.

In pedomorphosis there is a displacement of ancestral features to later stages of development. Certain ancestral traits are, as it were,

“pushed off” the end of individual development. As Julian Huxley says, “Previous adult characters . . . never appear because their formation is too long delayed: they are lost to the species by being driven off the time-scale of its development.” And, again, in another work, “The old adult characters may be swept off the map and be replaced by characters of a quite novel type.” In other words, the traits of old age drop out of the developmental program. It is not that one trait is displaced from one locus to another, but that it is either wholly or partially discarded or substantively modified. We have already mentioned as an example the replacement of the greatly developed brow ridges of early humans by the smooth supraorbital region of the fetus and child. The body hair of our ANTHROPOID ancestors has only been partially replaced by a relatively hairless skin, whereas the lower extremities have developed at an accelerated rate.

Neoteny and Human Biological Evolution

It is the possibility of escaping from the blind alleys of specialization into a new period of plasticity and adaptive radiation which makes the idea of pedomorphosis so attractive in evolutionary theory. Both its possibilities and limitations deserve the most careful exploration.

—JULIAN HUXLEY

The unique human trait of always remaining in a state of development is quite certainly a gift that we owe to the neotenous nature of mankind.

—KONRAD LORENZ

In surveying the development of the concept of neoteny it becomes clear that the morphological changes in the varieties of humankind have been brought about mainly by the retention into adult life of traits principally characteristic of the fetus. As Sir Arthur Keith put it, the outstanding structural peculiarities of humankind have been produced during the embryonic and fetal stages of its evolutionary history. It is not so much embryonic as fetal traits, however, that are neotenized both in the evolutionary and individual development of HUMANS. In the evolution of humankind from an anthropoid stock, it is easy to see that gradual change from anthropoid to human could have come about by the retention of the generalized fetal form of the anthropoid into adult stage.

Such retention of anthropoid fetal traits would come about in a mosaic manner, that is to say, not all fetal ancestral traits would be retained in descendant forms but only one or a few at a time. For example, in the australopithecines the front teeth (INCISORS and CANINES) underwent reduction, while the teeth at the side and back of

the jaws (PREMOLARS and MOLARS) retained their large size and only underwent reduction at a later time. The space between the canine (eye-tooth) and the first premolar, the premaxillary DIASTEMA, for the reception of the projecting canine of the lower jaw, remained quite wide in the juvenile australopithecine (Fig. 6) and reduced in later australopithecines. In the pithecanthropines (*Homo erectus*), a group that may well have originated from australopithecine stock, the premaxillary diastema is present in the earliest of the pithecanthropines, *Homo erectus robustus*, even though it is clear that the canine of the lower jaw had undergone reduction. In short, the space in the upper jaw remained, though it no longer served any useful purpose. Nevertheless, in later pithecanthropines the diastema completely disappeared. Another example of MOSAIC EVOLUTION is that while erect posture was attained by the australopithecines, brain size in the early forms did not appear to change much from that of their anthropoid ancestors. From *Homo erectus* to Neandertal man, through Solo man of Java, to modern man (*Homo sapiens sapiens*), we proceed by a step-like process to shed one anthropoid trait after another: the large teeth, projecting jaws, cranial crests, massive eyebrow ridges, and facial structures. Simply by stretching out the fetal stages of development and accelerating the rate of development of the brain, the trend is toward the retention of the structural traits of an ancestral fetus. The course followed in the structural evolution of humankind is schematically shown in Figures 7 and 8. In Figure 7 in the first column we see the skulls of newborn primates ranging from the rhesus monkey (*Macaca mulatta*) to a European. We see that all of them closely resemble each other. But reading from the bottom row across from the newborn to the adult male in the last column we can see that in the case of monkey and ape there is a marked change from pedomorphic to gerontomorphic form. Evidence of gerontomorphosis becomes progressively much less marked in the human forms, Neandertal, Australian aborigine, and European. Indeed, in these latter forms, as one progresses from Neandertal to European, the trend is markedly toward pedomorphism, the maintenance of the juvenile form of the skull. This would be even more strikingly evident were it possible to show a series of Chinese skulls ranging from newborn to adult males, for in the adult Chinese skull pedomorphism has proceeded further than in any other people. The Mongoloid skull generally, whether Chinese or Japanese, has been rather more neotenized than the Caucasoid or European (Table 1): The female skull,

it will be noted, is more pedomorphic in all human populations than the male skull; this holds true for many other somatic traits and, I have not the least doubt, for functional and behavioral traits as well (see Table 2). In other words, the female realizes the promise of the species rather more fully than the male.

In Table 3 I have listed some thirty neotenous physical traits in humans; some of these are obviously a reflection of others. For example, the globular form of the skull reflects the great increase in the size of the brain, while flatness of face, small jaws, and small teeth are each closely related to the others.

Neotenous functional or physiological traits in humans are many. Except for behavioral traits, these are listed in Table 4.

THE CRANIAL FLEXURE

In the EMBRYO of all MAMMALS and most vertebrates, Bolk pointed out, the axis of the head forms a right angle with that of the trunk; this is known as the cranial flexure. In all mammals, with the exception of humans, a rotation of the head occurs during the later stages of development so that the head assumes an orientation continuous with the direction of the backbone, as for example in the adult dog (Fig. 9). Humans, on the other hand, retain the cranial flexure. The visual axis, the line of sight, of both dog and human is horizontal; however, the dog's body is also horizontal while that of a human is perpendicular. In the adult great apes, being obliquely quadrupedal, the position of the body is in between, and the axis of the head is also intermediate. The FORAMEN MAGNUM, the aperture at the base of the skull through which the spinal cord passes down into the vertebral canal, is situated rather more posteriorly than it is from the central position it occupies in either fetal ape or human. It thus transpires that the human erect posture represents the retention in post-natal development of a fetal condition which in other mammals is limited to the period of embryonic or fetal development, that is, a horizontal visual axis and a vertical or perpendicular body. Increase in height and pelvic form are not neotenous, the one being due to HYPERMORPHOSIS, resulting largely from increase in length of the legs, and the other to accommodations to the erect posture.

These are simply statements of fact; they tell us nothing about causation—which is quite another matter, and one upon which we can only speculate. The most probable explanation is that in the

evolution of early humans the upright posture proved, in the environments in which they found themselves, to be of increasingly great adaptive value. Hence, in such circumstances, changes in the rate of development for the retention of the cranial flexure in relation to the perpendicular body were most likely to be selected.

Against the view that human erect bipedalism has been made possible by the retention of a neotenuous fetal relationship between the cranial flexure and body axis is the argument that changes in the pelvic girdle, the lower extremity and foot, and the differences in muscular attachments, especially the gluteus maximus (the large muscles of the buttocks), render it unlikely that neoteny in this connection has any explanatory value whatever. In the first place, it is said, such modifications are never present in the apes, either embryos or fetuses or at any stage of development, and in the second place some of these traits are not even to be found in fetal humans. Furthermore, a fundamental feature of the erect bipedal human is the elongated lower extremity, a trait the very opposite of neotenuous.

All these criticisms of Bolk's views are quite sound, but they do not in the least weaken his main argument, for he did not claim that erect bipedalism came into being as a sudden *MUTATION*. On the contrary, he appears to have understood that the development of the erect posture was quite gradual. However that may be, the hypothesis of neoteny does not exclude the operation of other factors in the development of the erect bipedal form of locomotion.

When we look at our contemporary primate relatives—the orangutan, the chimpanzee, and the gorilla—and observe the various postures they assume under different conditions, including erect ones, we experience no difficulty in reconstructing the stages through which our ancestors must have progressed to achieve our own erect bipedal posture.

Bolk also drew attention to the fact that the cranial flexure in adult humans is paralleled by what de Beer termed the pubic flexure. In the embryo of mammals the axis of the urogenital structures and rectum is directed downward, but in the adult mammal, with the exception of humans, the axis of these structures undergoes rotation so that it comes to lie parallel with the backbone, resulting in a backward direction of the vaginal aperture. By contrast, in humans the fetal orientation of these structures is retained, so that the vaginal aperture is directed downwards, a principal effect of which is the horizontal face-to-face posture standard in copulation.

THE POSITION OF THE FORAMEN MAGNUM

The central position of the foramen magnum at the base of the skull is another unique human feature among the primates. Interestingly enough, in infant nonhuman primates this foramen is more centrally situated than it is in adults. In these animals, during the growth of the skull, and especially of the jaws and face and the eruption of the teeth, the structure that contributes to the posterior and lateral margins of the foramen, the occipital bone, is pushed, as it were, backwards and upwards, so that the axis of the foramen frequently ends up facing backwards almost in the vertical plane. Fascinatingly enough one of our early progenitors in the line from the pithecanthropines to Neandertal man and so on to ourselves, namely, Solo man from Java, possessed a foramen magnum not quite as centrally situated as in modern humans, the anterior part of which was in the horizontal plane, while the posterior half was almost in the vertical plane. In suckling apes and humans the central portion of the foramen magnum is probably associated with the need for the head to be positioned erectly in nursing at the mother's breast. Here, too, a flat face is an advantage, owing to the peculiar mechanics of the breast-feeding situation. It is for the same reason that the jaws remain undeveloped in all suckling nonhuman primate infants who, like the baboons, will later develop a considerable muzzle. Toward the end of the suckling period in monkeys and apes, when weaning usually commences, the changes in the face and base of the skull lead to the gradual posterior positioning and orientation of the foramen. In humans the fetal position and orientation of the foramen remains unchanged. Hence, the infantile stage of development of these traits, as Keith pointed out, has become permanent in humans.

It might be thought, judging from the conditions prevailing in contemporary gatherer-hunter peoples, that the prolonged and intensive breastfeeding enjoyed by children in prehistoric societies, generally lasting some four to seven or more years, had some relation to the development of the erect posture in humans. However, since under natural conditions chimpanzees breastfeed for some five years, the principal factors operative in producing the erect posture have to be looked for elsewhere.

THE FACE AND THE FLEXURE

The bones of the face develop quite independently of those of the rest of the skull. The facial bones are the nasal, MAXILLA (upper jaw),

zygomatic (cheekbones), and MANDIBLE (lower jaw) (Fig. 10). Most of the other large cranial bones contribute to the formation of the brainbox, the sides, back, and base of the skull. The frontal bone also makes its contribution to the face as well as to the sides and base of the skull. The facial bones tend to be vertically inclined in humans, whereas in apes they tend to project in a more obliquely forward direction, largely as a result of the projection of the jaws, a condition called *prognathism*. In the early fetal development of primates conditions are quite different. In them the cranial flexure is found to be such that the anterior portion of the base of the skull is inclined downward, and the face is similarly inclined beneath the base. In the course of fetal development, however, the flexure straightens out, resulting in the apparent projecting jaws characteristic of all primates with the exception of humans. In humans the fetal flexure is retained, and it is this neotenuous condition that accounts for the ORTHOGNATHY or flat-facedness of humans. These views, using somewhat different terms, were set out by Bolk in a 1923 paper, "The Problem of Orthognathism."

Since orthognathy is confined to the early fetal stages of development in the apes, the neotenuous mutations that led to orthognathy must have occurred fairly early in hominid evolution.

The Nose

There is one feature of the human face which seems rather puzzling. It is the nose. The human nose is unique among primates, for it juts out like a peninsula left behind by the retreating verticalizing face. In the rush to reduce the prognathic jaw, it would seem, there was a failure to deal with the excess material that remained after the rearrangement of the facial bones. But that is not exactly what happened. Since PROGNATHISM makes possible a considerable surface area of vitally necessary mucous membrane within the nasal fossa and its associated structures, reduction of the jaws together with the mucous membranes of the nasal fossa would have constituted a selectively great disadvantage. Hence, the mucous membrane was retained by projecting it outward under cover of that complex organ we call the nose. Whether flat, long, broad, or narrow, whatever its shape, as long as the surface area of the mucous membrane remains adequate for the important functions it is called upon to perform during every moment of the individual's life, it matters not one bit what the external form of the nose may be.

If the nose does not appear to be a neotenuous trait, that is appearance only, for the manner in which it has come about in development is by retardation of the growth of the jaws and a retraction and rotation outward of the frontal processes of the upper jaw. This rotation comes about as if by crowding, so that the paired nasal bones, which are attached laterally to the frontal processes of the maxillary bones ascending upwards from the jawbones, are also pushed outward, thus producing for the first time in the primates the elevated form of the nasal bones, which together with the median septal cartilage result in the human nose. So the human nose, if not itself a neotenuous trait in the sense of having been retained by retardation from an earlier stage, is certainly the consequence of such a process affecting neighboring structures.

Dr. E. V. Glanville, in a study of nose shape, prognathism, and adaptation, found that with increasing prognathism there was an increase in the broadness of the nose. With retardation of jaw growth the jaws, as it were, withdrew, leaving the nasal aperture and the nose itself narrower and more prominent. Hence, we may conclude that the nose constitutes yet another example of the workings of neoteny.

The Sense of Smell

It has often been stated that humans have a poor sense of smell. This is quite untrue. The human infant is born with an acute sense of smell and when only a few days old is quickly able to distinguish the odor of its own mother's breastpad from that of any other breast-feeding mother. Olfactory ability is far from contemptible in humans and in a number of respects is not far below that of the dog. Compared, however, with that of the dog, the olfactory EPITHELIUM is much reduced in humans; nevertheless olfactory efficiency remains quite considerable into adult life, and, thus, the ability to smell as well as we do may be regarded as a non-neotenuous function of a neotenuous nasal structure. Far from becoming vestigial, as is sometimes claimed, the sense of smell plays an important adaptive role in alerting humans to the presence of a large variety of otherwise undetectable conditions.

It is conceivable that the nose would have remained exactly as it is in the apes had its projection not served some adaptively more useful purpose than olfaction. Had the nose not developed its prominence with the retraction of the jaws, it would have suffered a sig-