selection for lactase-sufficient adults was especially intense (Harrison 1975; Paige and Bayless 1978; Simoons 1982; Harris 1986).

ADAPTATION AND RACIAL ANTIQUITY

Because of the operation of evolutionary forces such as selection and gene flow, the traits that are used to define races today and in the recent past may not have existed as part of the same bundle in more remote times. No one knows what bundle of traits characterized populations 25,000 or more years ago. This is especially true of the soft parts of the body and of skin color, since these traits are not preserved in the fossil record. Modern-day images of racial types cannot be projected onto populations that lived tens of thousands of years ago, since our remote ancestors probably had entirely different bundles of polymorphisms and bore little resemblance to negroids, caucasoids, or mongoloids as we know them today.

The belief that today's races represent ancient breeding isolates is further contradicted by the adaptive effects of selection. As we have just seen, human polymorphisms may result from selection for advantageous alleles. If traits used for racial classification are strongly adaptive, they cannot be used as evidence of ancient common biological descent.

For example, suppose a group with a low-sickling frequency moves into an area of endemic malaria inhabited by an unrelated people who have a high frequency of sickling alleles. After a number of generations (predictable by genetic equations), the frequency of sickling will increase among the immigrants even if there is no intergroup mating, and after a relatively short time the natives and the immigrants will become indistinguishable with respect to the sickling trait.

As we shall see in the next section, there is a strong possibility that skin color—one of the most popular diagnostics of human racial groupings—is an adaptive trait and is therefore not a reliable indication of common ancestry.

SKIN COLOR

Most human beings are neither very fair nor very dark, but brown. The extremely fair skin of northern Europeans and their descendants, and the very black skins of central Africans and their descendants, are probably special adaptations. Brown-skinned ancestors may have been shared by modern-day blacks and whites as recently as 15,000 to 10,000 B.P.

Human skin owes its color to the presence of particles known as *melanin*, the same substance that allows lizards to change their color and makes octopus ink black. In humans the primary function of melanin is to protect the upper levels of the skin from being damaged by the ultraviolet wavelength of sunlight that penetrates the atmosphere. This radiation poses a critical problem for our species because we lack the dense coat of hair that acts as a sunscreen for most mammals. Hairlessness, as we have seen (p. 92), has its advantages: It allows abundant sweat glands to cool our bodies through evaporation, thereby bestowing on our species the unique ability to pursue and run down swift game animals over long distances during the midday heat. But hairlessness has its price. It exposes us to two kinds of radiation hazards: ordinary sunburn with its blisters, rashes, and risk of infection; and skin cancers, including malignant melanoma, one of the deadliest diseases known. Melanin is the body's first line of defense against these afflictions. The more melanin particles, the darker the skin and the lower the risk of sun-

burn and all forms of skin cancer (Malkenson and Keane 1985).

Malignant melanoma is primarily a disease of light-skinned individuals of northern European parentage with a history of exposure to intense solar radiation. One of the highest rates of all forms of skin cancer is found in Australia, where the white population is primarily of northern European descent. Solar radiation is implicated for two reasons: the rate quadrupled coincident with an increase in outdoor sports and the wearing of scanty attire; and the rate varies with the amount and intensity of solar radiation from north to south (Ariel 1981).

If exposure to solar radiation had nothing but harmful effects, natural selection would have favored inky black as the color for all human populations. But the sun's rays do not present an unmitigated threat. As it falls on the skin, sunshine converts a fatty substance in the epidermis into vitamin D. The blood carries vitamin D from the skin to the intestines (technically making it a hormone rather than a vitamin), where it plays a vital role in the absorption of calcium. In turn, calcium is vital for the growth and strength of every bone in the body. Without it, bones become soft and grotesquely deformed, and people fall victim to the crippling diseases rickets and osteomalacia (Figs. 6.6 and 6.7). In women, calcium deficiencies can manifest themselves in deformed birth canals, which make childbirth lethal for both mother and fetus (Malkenson and Keane 1985; Molnar 1985:162 ff.).

While vitamin D can be obtained from a few foods—primarily the oils and livers of marine fish—inland populations must rely on the sun's rays and their own skins for the supply of this crucial substance. The particular color of a human population's skin therefore represents in large degree a trade-off between the hazards of too much versus too little solar radiation: acute sunburn and skin cancer on one hand, and rickets and osteomalacia on the other. It is this trade-off that largely accounts for the preponderance of brown people in the world and for the general tendency for skin color to be darkest among equatorial populations and lightest among populations dwelling at higher latitudes.

At middle latitudes, the skin follows a strategy of changing colors with the seasons. Around the Mediterranean basin, for example, exposure to the summer sun brings high risk for cancer but low risk for rickets; more melanin is produced and people grow darker (i.e., they get suntans). Winter reduces the risk of sunburn and cancer; less melanin is produced and the tan wears off.

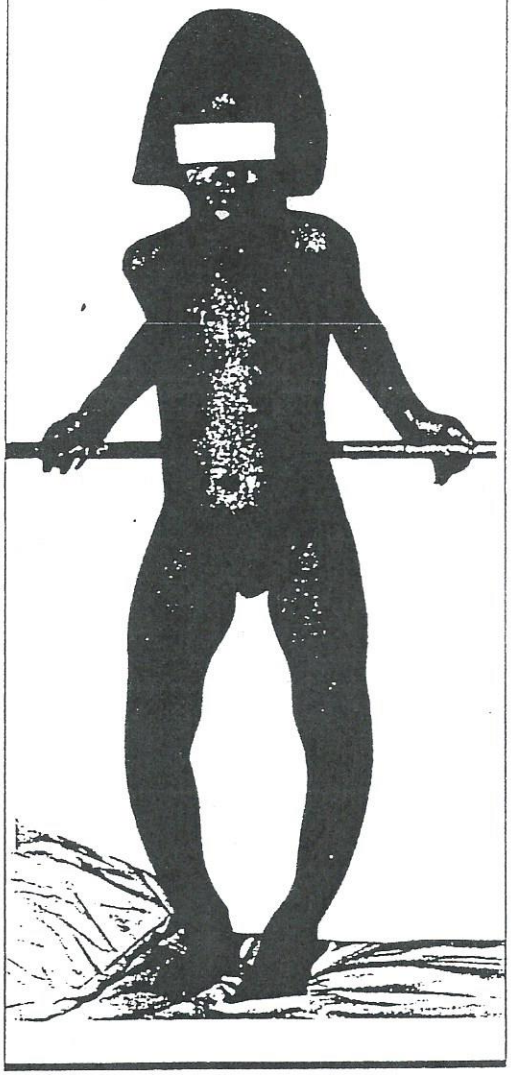
The correlation between skin color and latitude is not perfect because other factors —such as the availability of foods containing vitamin D and calcium, regional cloud cover during the winter, amount of clothing worn, and cultural preferences—may work for or against the predicted relationship. Arctic-dwelling Eskimos, for example, are not as light-skinned as expected, but their habitat affords them a diet that is exceptionally rich in both vitamin D and calcium.

The Origin of White Skin

The Mediterranean farming and dairying people who settled northern Europe about 6000 years ago (see p. 198) must have been acutely endangered by rickets. As they migrated northward they had to cover themselves with heavy garments for protection against the long, cold, cloudy winters. But unlike the Eskimo, their farming and dairying economy did not provide them with marine fish rich in vitamin D. Fair-skinned, nontanning individuals who could utilize the weakest and briefest doses of sunlight to synthesize vitamin D would have been strongly favored by natural selection. During the frigid winters, only a small circle of a child's

FIGURE 6.7

RICKETS
A young victim.



face could be left to peek out at the sun through the heavy clothing, thereby favoring the survival of individuals with translucent patches of pink on their cheeks characteristic of many northern Europeans.

Depigmentation went a long way toward solving the problem of producing vitamin D in the skins of these displaced Mediterraneans. But vitamin D by itself will not prevent rickets. There also has to be an adequate intake of calcium. The dairy animals that the migrants had with them were a splendid resource in this regard. Not only is milk rich in calcium but it has recently been discovered that the sugar in milk—lactose—also facilitates the absorption of calcium (Simoons 1982). But in order to take advantage of the antiricketic properties of milk, another genetic obstacle had to be overcome: the migrants had to acquire the ability to digest lactose in adulthood as well as childhood. Malabsorption of large quantities of lactose leads to debilitating cramps and diarrhea, conditions that are adverse for calcium absorption (or digestion in general). So it is no accident that northern Europeans have both distinctively fair skins and an unusual ability to digest copious quantities of fresh fluid milk.

If light-skinned individuals on the average had only 2 percent more children per generation, the changeover in their skin-color gene frequencies could have begun 6000 years ago and reached present levels well before the beginning of the Christian era (Cavalli-Sforza 1972). But natural selection need not have acted alone. Cultural selection may also have played a role. It seems likely that whenever the northern farmers consciously or unconsciously had to decide which infants to nourish and which to neglect, the advantage would go to those with lighter skin, experience having shown that such individuals tended to grow up to be taller, stronger, and healthier than their darker siblings, despite their inability to tan.

The Origin of Black Skin

To account for the evolution of black skin in equatorial latitudes, one has merely to reverse the combined effects of natural and cultural selection. With the sun directly overhead most of the year, and clothing a

hindrance to work and survival, vitamin D was never in short supply and calcium was easily obtained from vegetables. Rickets and osteomalacia were rare. Skin cancer was the main problem, and what nature started, culture amplified. Darker infants were favored by parents because experience showed that they grew up to be freer of disfiguring and lethal malignancies.

It is interesting to note that the darkest-skinned Africans inhabit the most heavily forested parts of Africa. One of the negative aspects of heavy pigmentation is that the skin absorbs heat in direct proportion to its darkness. Thus it is known that blacks are about 15 percent more susceptible to heat stroke than whites (Baker 1958). Increased susceptibility to heat stroke might be a serious disadvantage in hunting and running down animals in open or savannah habitats. But if hunting took place primarily in tropical forest settings, the negative effect of very dark skin would not be significant.