which was recently included in the "Greater St. Petersburg". A set of small maps on different groups of diseases reflects a very complicated geography in connection with industrial zones, the city center and sometimes for reasons that are not related to ecological factors.

The map of integral evaluation of the city environment, which concludes the Atlas, condenses the data (Fig.1). Environmental conditions in the historic core of St. Petersburg are no worse than those in the industrial belt east and south of the city center. The best conditions are found on the Neva delta islands with parks, and at the northern and southern ends of the city.

CONCLUSION

It is thought that electronic media and communications are replacing traditional means of information such as books and maps. We do not think so. Although, electronic maps and GISs have great prospects as powerful tools for environmentalists and geographers. Paper maps and atlases have their own users. The great interest in the *Environmental Atlas of St. Petersburg* shows that it is very convenient type of data presentation for decision makers and municipal administration; architects and city planners; school and university teachers; and ordinary citizens interested in and troubled over environmental issues. The Honorary Diploma of the Russian Geographical Society to all the participants in the project for Atlas com-pilation is a mark of high scientific recognition of the work carried out. At the moment a similar *Atlas of Kaliningrad City* is being completed by our team of experts, and work is in preparation for the city of Togliatty (the automobile and chemical industry center on the Volga river).

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Synopsis

Vitamin D Deficiency: Global Climatic Change and Environmental Pollution

Vitamin D is essential for the mineralization of bones in both animals and humans, through its actions on bone, intestine, and kidney by promoting calcium homeostasis (1). Vitamin D is formed in skin exposed to solar irradiation, but alternative forms of the vitamin can also be obtained from food (2). Skin and dietary precursors are activated through specific metabolic reactions in the liver and kidneys (3).

The efficiency of vitamin D synthesis in the skin depends on the intensity of ultraviolet light from solar irradiation and is affected by several factors; latitude and seasonality being the most important (1).

The efficiency of synthesis increases with shorter distance to the equator. As the angle of the incident sunlight becomes smaller at higher latitudes or in winter, the efficiency of synthesis diminishes rapidly. The influence of seasonality is clearly observed in the variation of plasma levels of vitamin D throughout the year, with the highest levels occurring in late summer and the lowest in late winter (3). The efficiency of synthesis of vitamin D in the skin can be further reduced by the presence of fog, clouds or dust in the atmosphere (1, 4), and by skin cover (clothes, wool, hair) and pigmentation (4). Smog is an important factor in highly industrialized or polluted areas (5). On the other hand, altitude and solar irradiation reflected in water or snow increase the efficiency of synthesis (2).

The availability of vitamin D in the diet of herbivores is dependent on several factors. Vitamin D is not formed in green forage leaves, and is present in only low quantities in seeds. Only properly irradiated dead leaves contain the active compound (2). The deficiency in food is also enhanced by the antivitamin D effects of carotenes and /or other factors found in growing green plants (4, 6). Human sources of vitamin D are irradiated skin and diet, the former being the most important (3).

DEFICIENCY

Low solar irradiation impairing skin synthesis, low availability of dietary precursors and/ or disorders in the metabolic pathways can cause vitamin D deficiency (5, 6). This deficiency produces abnormal mineralization in juveniles (rickets) and adults (osteomalacia) and is typically evidenced in juveniles by a thickening of endocondral junctions, bowing of large bones and swelling of joints. Juveniles and adults may also have softened bones that are more susceptible to fractures (5, 6).

Descriptions of vitamin D deficiency in domestic herbivores have been typically related to extreme latitudes with high availability of green grasses. Examples are New Zealand, South Australia, and the United Kingdom (4, 6). In humans, the problem is also common in high latitude regions (1, 5).

It is apparent from these observations that many of the factors that regulate the supply of vitamin D are strongly influenced by climate and can be affected by changes that may occur in relation to global warming. There is a high degree of uncertainty in predictions, particularly in relation to the secondary effects of temperature and atmospheric circulation patterns such as precipitation or soil moisture. Some consensus exists for a seasonal increase in rainfall at high latitudes (7, 8). What would be the consequences of these changes on vitamin D status in animal and human populations?

VITAMIN D AND PERIODONTAL DISEASE: AN ONGOING PROJECT AND HYPOTHETICAL EXAMPLE

This question arose when a skull of a huemul (*Hippocamelus bisulcus*), an endangered deer from the southern Andes, was sent in 1990 to our laboratory with strong periodontal lesions. A research project is now attempting to identify the prevalence and pathogenesis of periodontal disease in wild mammals. One of the main objectives is to evaluate whether vitamin D deficiency can, at least in part, be responsible for the disease and, if this is the case, to consider the potential climate-change related consequences. But, what relationships are there between vitamin D and periodontal problems?

Periodontal disease in sheep is, probably, a multicausal problem, particularly severe in New Zealand and Scotland (4). This disease may be useful as a domestic animal model for periodontal disorders in wildlife. It is characterized by different kinds of lesions, e.g. chronic gingivitis, excessive incisor wear, periodontitis, and tooth loosening and loss (4). Other lesions that may be associated with the problem are: abnormal eruption of permanent teeth, dentigerous cysts, mandi-bular osteopathy and jaw swellings (9–11). The causes are still not clear, but nutritional (12, 13), traumatic (10), bacterial (14) and genetic (15) factors seem to be involved. Although bacterial periodontitis is nearly always present when the disease is well developed (14, 16), any factor affecting maxillar structure and dental attachment could predispose to the disease. Indeed, low calcium values in serum detected in New Zealand (17), low mandibular radiographic density detected both in Scotland (11) and in New Zealand (12) and improvement in incisor conditions through calcium and phosphorus supplementation (13) suggest that systemic factors affecting bone metabolism and structure are present.

Softening and weakness of maxillar bones and malocclusion of molar teeth have been associated with phosphorus and vitamin D deficiency in sheep (18, 19). Fibrotic osteo-

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dystrophy, a disorder present in some phases of this deficiency (5, 6), causes severe softening of maxillar structure with dental loosening and loss, in all domestic species (6). Thus, vitamin D deficiency could be playing a role in the pathogenesis of periodontal disease, not only because it can produce the predisposing lesions but also because both occur in similar geographical locations; regions at high latitudes with an abundance of green forage.

Clinical and pathological findings characteristic of periodontal disease were recently described in sheep in southern Argentina, at about latitude 42°S (20).

A review of periodontal disease in wild herbivores shows that the majority of the descriptions were reported at high latitudes: reindeer (*Rangifer tarandus*) in South Georgia (latitude about 54°S) (21); caribou (*Rangifer tarandus*) in northwestern Alaska (22) and northern Canada (23); Dall's sheep (*Ovis dalli dalli*) in northwestern Canada (23); chamois (*Rupicapra rupicapra* L.) (25) and feral goats (*Capra hircus* L.) in New Zealand (26); guanaco (*Lama guanicoe*) (Latitude 42°S and 55°S) (27, 28) and huemul (*Hippocamelus bisulcus*) (Latitudes 43°S) (29) in southern Argentina.

Periodontal disease, mainly described in herbivores, has also been detected in other mammals such as pinnipeds. It was diagnosed in the Aleutians (latitude 54°N) in prehistoric sea lions (*Eumetopias jubatus*), and sea otters (*Enhydra lutris*) (30). A leopard seal (*Hydrurga leptonix*), from the South Atlantic Ocean, was found on the Argentinean coast in 1944 bearing an osteomyelitis of both maxillars and a periodontal disease (31).

Although the studies of these wildlife diseases were based mainly on bone analyses, the particular distribution in high latitude areas and the complex hormonal and mineral interactions that regulate bone homeostasis, suggest that vitamin D deficiency might have played an important role in the pathogenesis. A causal relationship with periodontal disease would determine that environmental changes affecting vitamin D could be responsible for the historical prevalence of the problem.

An interesting study of periodontal lesions in grey seals (*Halichoerus grypus*) (32) and harbor seals (*Phoca vitulina*) (33) from the Baltic Sea, indicated that the problem has been present at least since the 19th century. The authors detected an increased prevalence of skull lesions collected after 1960 in grey seals (32), and since the turn of the last century in harbor seals (33). Organochlorine pollutants, were suggested to contribute to the increased prevalence, because of their suspected effects in producing high levels of glucocorticoids (hyperadrenocorticism); compounds that can produce bone porosity (32, 33). Vitamin D deficiency may also have played a role in these cases, not only because of climate change, which could have occurred in the last decades, but also for the fact that glucocorticoids can diminish the number of vitamin D receptors in bone and intestinal mucosal cells (1). Even when fish—particularly the liver—have high vitamin D concentrations, hepatic tissue can also accumulate high concentrations of cadmium as in several marine species such as oysters, crabs and mussels (34). Cadmium was another pollutant detected in seals, with increasing concentrations with age (35). Cadmium chronic toxicity is characterized by renal damage and osteomalacia in humans, as was described after an episode of chronic ingestion of highly contaminated rice in Japan (34).

In addition, decreasing levels of vitamin D in serum have been observed in cadmium-induced renal damage; evidence that vitamin D could be seriously involved in the pathogenesis of cadmium-induced osteomalacia (36). Thus, it may also have played a role in the skull lesions of seals.

CONCLUSION

The causal relationship between vitamin D and periodontal disease in mammals is a hypothesis that needs to be investigated, and which poses some major questions. Different factors could be altering vitamin D availability: smog, through the decrease in solar irradiation; environmental pollutants, through metabolic dysfunctions; and climate change through the reduction of sunshine hours and other indirect effects. Thus, these environmental changes could be altering the epidemiology of vitamin D deficiency.

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