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A PROPOSED SECONDARY SCHOOL BIOLOGY SYLLABUS FOR UGANDA.

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A PROPOSED SECONDARY SCHOOL BIOLOGY SYLLABUS FOR UGANDA

by

Robert Alvin Hellmann

This project was done under the supervision of:

Professor O. Roger Anderson, Sponsor
Professor Willard Jacobson

Approved by the Committee on the Degree of Doctor of Education

Date MAY 2 1966

Submitted in partial fulfillment of the requirements for the Degree of Doctor of Education in Teachers College, Columbia University

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Digest

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Statement of the Problem

This study is an examination of those current social and economical problems of Uganda which are related to the field of biology and their implications for instruction in biology in Uganda. The syllabi for the Cambridge School Certificate and Higher School Certificate Examinations in the biological sciences are reviewed in the light of those problems, and revised syllabi are presented.

Methods

The resources of the library of Makerere University College, Kampala, were examined for relevant literature on East African education. The report of the International Bank for Reconstruction and Development, "The Economic Development of Uganda. (1961), was used extensively as a comprehensive source of information. Annual and special reports of various Uganda government agencies, such as the Department of Agriculture, the Department of Education, and the Game and Fisheries Department, were reviewed. United Nations sources of information included the Chronicle of the World Health Organization and various reports and papers of WHO, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and the Food and Agriculture Organization (FAO).

Publications of prominent wildlife biologists were reviewed for scientific data in their fields. Interviews and correspondence with specialists in public health, agriculture, education, and conservation in Uganda supplied further information.

While performing educational services during a one-year period in Uganda, the author visited and interviewed teachers in secondary schools in Uganda, Kenya, and Tanganyika. Most of the national parks throughout East Africa, including both national parks in Uganda, were visited and observed. During the period the author had occasion to talk with Uganda Africans, including students, teachers, and others.

Results

The major biological problems of social and economic development in Uganda lie in the fields of public health, agricultural production and marketing, and wildlife conservation. Public health problems are chiefly those of parasitic and infectious microbial diseases and control of vectors. Prominent among these are malaria, hookworm, schistosomiasis, Filariasis, and, potentially, yellow fever. Control of these diseases is complex and requires extensive knowledge of the ecology of vectors as well as life cycles of pathogens. Kwashiorkor is the only serious dietary disease, but it afflicts many children;

it can be corrected through enlightenment.

Problems of agricultural development are largely matters of quality of produce, soil management, plant and animal breeding, and pests and diseases of crops and cattle. Trypanosomiasis precludes use of substantial areas for cattle raising at present. Peasant farmers, who produce the bulk of cash crops, need to be taught intelligent management of soils to maintain fertility and soil texture and structure. Extension services are critically needed.

A critical shortage of wildlife and parks personnel is due to lack of interest among young Africans for field work in biology. Overproduction of hippopotamus, the decline of rhinoceros, lack of knowledge of specific ecological requirements of various game species present problems for intelligent planning of wildlife conservation policies and measures.

The currently used Cambridge syllabi are designed for use in English schools; treatment of subject matter directly relevant to the above problems is inadequate. A need for revision is therefore seen, and, in the light of these findings, revised syllabi are presented, with an emphasis on ecology, plant physiology, vector life cycles and personal health, and genetics.

ACKNOWLEDGEMENTS

The author wishes to express his indebtedness to the members of his committee, Dr. O. Roger Anderson, Dr. Willard Jacobson, and Dr. Frederick L. Fitzpatrick, for their guidance in the pursuit of this study and the preparation of this report. He also wishes to thank the following for their kind cooperation in providing information through correspondence and interviews: Col. C. D. Trimmer, Uganda National Parks; Mr. E. Okello and Mr. G. W. Oguli, Uganda Ministry of Education; Mr. Senteza Kajubi and Mr. Harry Creaser, Institute of Education, Makerere University College; Dr. Norman E. Wilks, Uganda Medical Department; Mr. D. O. Mathews, East African Tourist Travel Association; and Miss Ulrica Blume, Swedish Information Service, New York. Special thanks are also due to the Cambridge University Local Examinations Syndicate for their kind permission to quote the biological science portions of the School Certificate and Higher School Certificate syllabi for purposes of this study.

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CHAPTER I

INTRODUCTION

Statement of the Problem

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Limitations

The study applies specifically to Uganda and is limited to biology in the senior secondary and higher school levels.

Basic Assumptions

1. East African countries are undergoing rapid cultural change from pastoral and primitive agrarian traditions to a modern civilization. The technological problems involved in the change are enormous. Therefore, a highly utilitarian outlook on science education is justifiable.

2. Curricula should be designed in terms of community and national needs and interests. If current biology instruction omits broad areas of concern to Uganda, changes in the curriculum are in order.

3. No curriculum is suitable for all communities at all times.

Educational Significance

In view of the fact that conditions in Uganda are undergoing rapid changes, almost inevitably any curricula tend to become obsolete in a relatively short time. This study has attempted to reveal biological principles and applications important in relation to existing conditions and thus point the way to modern curricula.

Review of the Literature

The earliest attempts at European education in Uganda were undertaken by Anglican and Roman Catholic missionaries near the end of the last century.[1] The purpose of such instruction was to teach Christian morals and the lessons of the Bible and the Church. From these

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[1]Rt. Rev. J. J. Willis, "Some Aspects of Education in Uganda," Some Aspects of Education in East Africa ("University of London Institute of Education Studies and Reports," No. IX (London: Oxford University Press, 1936)), pp. 47-48.

early missionary attempts, the need for an expanded educational system evolved, and in the 1920's the total educational program in various regions of Africa came under review. In their report on education in West, South, and Central Africa, the Commission on African Education,[1] operating under the auspices of the Phelps Stokes Fund, strongly urged "the adaptation of education to the needs of the people.... as the first requisite of school activities." The report claimed that indifference shown toward education in Africa was due largely to the lack of direct relevance of the school work to local African conditions. In a separate report published subsequently for East Africa,[2] the principle of adaptation of education to community life was applied to East Africa. Specifically, the 1922 report[3] recommended the following subjects for study in all secondary schools: science; physiology; hygiene and sanitation; mathematics; gardening and rural economics; and several non-science subjects. However, it was not the purpose of the commission to recommend detailed syllabi.

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[1]Thomas Jesse Jones, Education in Africa: Report of the African Education Commission (New York: Phelps Stokes Fund, 1922), pp. 11-12.

[2]Thomas Jesse Jones, Education in East Africa: Report of the African Education Commission (New York: Phelps Stokes Fund, 1925).

[3]Thomas Jesse Jones, Education in Africa: Report of the African Education Commission (New York: Phelps Stokes Fund, 1922), pp. 66-68.

In 1929 Professor Julian Huxley visited Zanzibar, Tanganyika, Kenya, and Uganda on the recommendation of the Advisory Committee on Native Education in Tropical Africa. Again, he proposed no detailed syllabus, but wrote that because man is an organism living in communities, whose activities are perpetuated through traditions, then an education system must provide man with an understanding of his physical and intellectual machinery; the curriculum must be rooted in local natural history and social tradition; and biology must play a leading role in an East African curriculum because of the importance of agriculture and public health to the future well-being of the area.[1]

Little else related to the syllabus appears until 1948, presumably in part because the efforts of the British were directed elsewhere due to world conditions between 1938 and 1945. In 1948 L. J. Lewis[2] commented on the tendency to pattern secondary schools after those in England, and attributed this in part to the need for establishing equivalency of standards to meet the external examination for entry into university and civil service work, and partly to the general lack of understanding of

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[1] Julian Huxley, "A Biological Approach to Education in East Africa," Oversea Education, II, 1 (Oct., 1930), 1-13.

[2] L. J. Lewis, Equipping Africa (London: Edinburgh House Press, 1948), pp. 14-15.

African community life on the part of expatriate teachers and school administrators.

A group widely known as the "deBunsen Committee,"[1] commissioned by the Uganda government, recommended separation of those interested in agriculture to special agricultural schools after eight years of schooling. At the Conference on African Education, held at London in 1953 under the auspices of the Nuffield Foundation, it was recommended that agriculture be integrated into the biology syllabus for junior secondary schools (grades 7 and 8): "It is important that those who go on to the secondary schools be aware of the paramount importance of agriculture and the dignity of manual tasks."[2] The Conference report then went further, and suggested twelve topics for a junior secondary agriculture-biology syllabus, and criticized the lack of relationship between the syllabus and the needs of Africa: "The effect of the examination is to turn Science into a departmentalized series of disciplines unrelated to the major agricultural needs of Africa."

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[1]Committee on African Education in Uganda, Report (Entebbe: Government Printer, 1953), pp. 35-36.

[2]Conference on African Education, African Education: A Study of Educational Policy and Practice in British Tropical Africa, Sponsored by the Nuffield Foundation (Oxford: Oxford University Press, 1953), p. 91.

Other papers have appeared from time to time which are chiefly descriptive and deal with the history of education in East Africa in a general way. A number have pointed to the problem of making the curriculum suitable to Africa, and a few have also mentioned the resistance occasionally shown by the Africans to such an adaptive policy,[1,2,3] and the tendency of African pupils to resent teachers' deviation from the syllabus as it stands.[4]

Methods

At the outset, the resources of the library of Makerere University College, Campala, were examined for relevant literature on East African education. Following this, the report of the International Bank for Reconstruction and Development, "The Economic Development of Uganda" (1961), was used extensively as a comprehensive source of information. In addition, annual and special reports

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[1]Lionel Elvin, Education and the End of Empire ("Studies in Education, University of London Institute of Education," No. 8 (London: Evans Bros., 1956)), pp. 18-19.

[2]Franklin Parker, African Development and Education in Southern Rhodesia (Columbus: Ohio State University Press, 1960), p. 73.

[3]Margaret Read, Education and Social Change in Tropical Areas (London: Thos. Nelsen & Sons, Ltd., 1955), p. 31.

[4]William W. Brickman, "Tendencies in African Education," Education Forum, XVII, 4 (May, 1963), 399-416.

of various Uganda government agencies, such as the Department of Agriculture, the Education Department, and the Game and Fisheries Department, were reviewed. United Nations sources of information included the Chronicle of the World Health Organization and various reports and papers of WHO, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and the Food and Agriculture Organization (FAO).

Scientific papers and books of prominent wildlife biologists, such as Sir Julian Huxley, Dr. George A. Petrides, Dr. Wendell Swank, and Dr. Bernhard Grzimek, were reviewed for scientific data in their fields. Interviews and correspondence with specialists in public health, agriculture, education, and conservation in Uganda supplied further information.

While performing educational services during a one-year period in Uganda, the author visited and interviewed teachers in secondary schools in Uganda, Kenya, and Tanganyika. Most of the national parks throughout East Africa, including both national parks in Uganda, were visited and observed. During the period the author had occasion to talk with Uganda Africans, including students, teachers, and others.

The information in this paper is based on the above sources, and the proposals for curriculum modification are made on the basis of this information.

CHAPTER II

THE LAND AND THE PEOPLE

The Land

Uganda is the emerald of East Africa. Smaller than either Kenya or Tanganyika, it occupies over 90,000 square miles north of Lake Victoria and west of Kenya. To the north lie the sandy wastes of the Sudan. Volcanic cones, mountains, lakes, and the upper reaches of the Nile separate the country from the rain forests of the Congo. Uganda is generally flat, consisting of a peneplain which is tilted downward toward the north. The southern edge, at Lake Victoria, has an elevation of about 4,000 feet and is dissected into numerous flat-topped hills. The Victoria Nile, flowing out of Lake Victoria at Jinja, winds its way northward and westward through a maze of papyrus marshes and the sprawling Lake Kyoga and joins the effluence from Lake Albert on the west to form the headwaters of the White Nile. These extensive wetlands, together with abundant rainfall, provide Uganda with lush native vegetation and productive farms throughout the southern half of the country. By contrast, the northern half is much drier, varying from sparse veldt through steppe to semi-arid brush country.

Most of the major relief features of the country are extinct volcanoes, great black masses thrust up on an otherwise level or hilly land. Chief among these is Mt. Elgon, in the Eastern Province. Its towering 14,000-foot crown is surrounded by prosperous banana, plantain, and coffee farms on the fertile lower slopes. More impressive, though rarely seen, are Uganda's only true mountains, the Ruwenzori, the mist-enshrouded and glaciated crests of which lie in the north-south direction between the equator and latitude one degree north, and separating Uganda from the Congo's Semliki Valley. Lying near these great fault-blocks are numerous volcanic cones. In the Kigezi District, in extreme southwestern Uganda, these cones reach their greatest development. There the rainy slopes are densely populated by peasant farmers practicing intensive contour crop planting. Unoccupied portions of the slopes are clothed by thick wet forests.

Between these two regions, a great belt of productive cotton, coffee, plantain, and sugar cane farms lies across south-central Uganda. This is the area of greatest economic development and progress. Besides these farms, many of which produce crops for export as well as local urban consumption, we find rapidly growing modern cities and towns, which only half a century ago were tribal capitals and fishing and trading centers. Kampala, originally and presently the capital of the native kingdom of Buganda, is now in addition the nation's capital, a cultural center, and the site of Makerere University College, which serves all of East Africa. Jinja, located on the shore of Lake Victoria east of Kampala, is the site of a hydroelectric dam which supplies power to most of southern Uganda, a cotton textile mill, and a number of other thriving new industries.

The total land area of Uganda is about 94,000 square miles, or about the size of the United Kingdom.[1] Of this area, much is covered by lakes and marshes, including the large irregular Lake Kyoga near the center of the country. Excluding these wet areas and the two national parks in the west, the total land area available for occupation is about 75,000 square miles. It has been suggested that of this, at least one-tenth should be maintained as permanent forest, and that as another portion of the land is unproductive and rocky, a remainder of 65,000 square miles could be considered fit for agricultural use.[2]

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[1]Uganda Relationships Commission, ed. Earl of Munster, Report (Entebbe: Government Printer, 1961), p. 7.

[2]E. B. Worthington, A Development Plan for Uganda (Entebbe: Government Printer, 1946), pp. 7-8.

The People

The total population of Uganda, according to the 1911 census, was 2,693,325. By 1931 it had risen to 3,584,758. By 1944 the figure was 3,956,654.[1] According to the 1959 census,[2] the African population had risen sharply to 6,450,973. There are in addition about 72,000 residents of Indian ancestry and about 10,000 Europeans,[3] whose presence is largely temporary and whose function is mostly to provide administrative and professional services. The census showed the south to be by far the more densely populated portion of the country (171 per square mile for Eastern Province as a whole, as opposed to 39 per square mile for Northern Province as a whole).

The people occupying the southern half of the country are predominantly Bantu-speaking Negroes, whose main occupation has traditionally been farming and, on the lake shore, fishing as well. Farming in the old peasant manner is normally done by the women, using a jembi, or grubhoe, after the land has first been cleared by the men. Each family farming at subsistence level cultivates

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[1] E. B. Worthington, A Development Plan for Uganda (Entebbe: Government Printer, 1946), pp. 7-8.

[2] Uganda Ministry of Economic Development, Statistics Branch, Uganda Census, 1959: African Population (Cyclostyle (Entebbe: The Ministry, 1961)), pp. 4-5.

[3] International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), pp. 4-5.

no more than about four acres.[1] In addition, a number of farmers grow a surplus of foodstuffs for local markets, or cotton or coffee for export.

Though there are differences in some details, the tribes of this region are all culturally related, and the languages so similar as to be often mutually comprehensible when the tribes are adjacent. For example, a Munyoro and a Mutoro can converse with each other, each using his own language. Similarly, a Muganda and a Musoga. The most important of these tribes are the Baganda, centering chiefly about Kampala, and numbering over a million, who at one time had subjugated related tribes to the east all the way to Mt. Elgon. Today, Baganda settlers are common on the slopes of Mt. Elgon. Perhaps the most impressive testimony of the importance of the Baganda is the fact that Luganda, their tribal language, is required to be taught in all the primary schools throughout the country, and is the lingua franca and intertribal language of most of Uganda.

North of the Kingdom of Bunyoro, the inhabitants along the Nile in northwestern Uganda belong to a linguistic group known as Nilotes. They are politically less well advanced than the Bantu and at present live

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[1]E. B. Worthington, A Development Plan for Uganda (Entebbe: Government Printer, 1946), pp. 7-8.

on a mixed economy of cattle-raising, hoe-farming, fishing, and perhaps hunting. This condition does not appear to be changing rapidly at the present, although cotton-growing is spreading into the West Nile now. Young men of the West Nile tribes often serve with the police and army.

The rest of the northern and, in particular, north-eastern part of the country is occupied by Nilotic and Nilo-Hamitic peoples, whose main occupation is cattle-raising. The country in the north and more especially the northeast, being arid steppe country, is generally not suitable for farming. Although much of this land has from 40 to 60 inches of rain per year, it is highly seasonal and undependable, often occurring as violent storms. The prospect of crop failure due to drought is therefore high. In the Karamoja District in the extreme northeast, the rainfall is well under 40 inches, ranging down to near desert levels. There the people are nomadic, primitive, warlike cattle herders, and intertribal warfare is common, in association with cattle thieving. These people are highly conservative, and changes in living patterns will not come about soon.

CHAPTER III

AGRICULTURE IN UGANDA

"It is our view that, in the present circumstances, investment in agriculture will bring greater returns -- in terms of expanded output and incomes -- than comparable investment in almost any other sector of the economy." --- International Bank for Reconstruction and Development, The Economic Development of Uganda.

History

The primary importance of agriculture to Uganda's economy, and to East Africa's economy as a whole, has been recognized for four decades at least.[1,2,3,4] There are several reasons for this. Though the soils of Uganda are subject to rapid deterioration under the tropical sun when not properly managed, they have been

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[1]Thomas Jesse Jones, Education in Africa: Report of the African Education Commission (New York: Phelps Stokes Fund, 1922), pp. 67-68.

[2]Julian Huxley, "A Biological Approach to Education in East Africa," Oversea Education, II, 1 (October, 1930), 1-13.

[3]International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), p. 78.

[4]Uganda Relationships Commission, ed. Earl of Munster, Report (Entebbe: Government Printer, 1961), p. 8.

highly productive for some time, at least in the more humid southern half of the country, where most of the nation's people live. The bedrock underlying most of Uganda is composed of ancient granites and gneisses. Though soils arising from such parent materials in the tropics are normally low in fertility, in the south one member of the catena, on the middle slopes of the hills, is well structured and contains ample nutrients. Toward the north this member becomes progressively narrower and eventually disappears. Combined with well distributed rainfall, the fertility has contributed to a high productivity.[1] But these soils must be managed carefully in order to maintain their fertility and high productivity. An important component of these soils is the organic residues. Phillips[2] points out that "when these soils are first deforested nitrogen is ample, the satisfactory organic matter content and the good texture permitting absorption of copious rain. After several years cultivation under insolation the organic reserves are depleted, the structure is destroyed and erosion ensues." The role of organic matter in maintaining water, proper soil structure, and

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[1] C. C. Wrigley, Crops and Wealth in Uganda ("East African Studies," No. 12 [Kampala: East African Institute of Social Research, 1959]), p. 3.

[2] John Phillips, Agriculture and Ecology in Africa (New York: Frederick A. Praeger, 1960), p. 139.

the moderate temperature conditions cannot be overemphasized in tropical agriculture, and the rapid oxidation of organic residues under exposure to sunlight is one of the great limitations to intensive farming in the tropics.

Most of the denser population of the south are traditionally farmers, and many of them, especially the Baganda, have been highly successful at producing cash crops for the market. A substantial corps of trained manpower is not yet available for industrial expansion, whereas the untrained men can at least feed themselves through peasant farming as their knowledge and skills permit. Advancement in agricultural knowledge among this peasant population is, however, imperative, because of the danger of rapid deterioration of soils through ignorance in management.

Earlier in the century an attempt was made to settle Uganda with white farmers after the fashion of the Kenya Highlands. Some settlers did arrive, and were moderately successful for a while in rubber and coffee plantations. Wrigley[1] gives a detailed account of the history of the parallel development of both peasant cotton growing and white plantations. In 1920 a slump in export prices of

[1] C. C. Wrigley, Crops and Wealth in Uganda ("East African Studies," No. 12 [Kampala: East African Institute of Social Research, 1959]), 84 pp.

both rubber and coffee brought to a climax a series of difficulties which had gradually begun to set in, and forced the planters out of business. In the meantime, officials of the Uganda administration began to see cotton in the hands of African small farmers as holding more promise for agricultural prosperity in the country. Thereafter, official policy was directed toward the encouragement of expansion of small operations by indigenous farmers. A considerable amount of low-grade coffee, of a species, Coffea robusta, which is native to Uganda and the Congo, was added to cotton. Unlike the higher grades of coffees grown by the white planters, this species is well suited to the low elevations and fairly high temperatures of most of Uganda. One species of higher quality, C. arabica, has since been introduced into Bugisu, on Mt. Elgon, where it thrives. Though unspectacular, the progress of African-owned agriculture has been steady, especially among the Baganda and Basoga.

At present Uganda's agricultural economy is moving actively from subsistence level peasant farming to commercial cash crop production for both internal consumption and export. Some statistics presented by the International Bank for Reconstruction and Development[1]

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[1]International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), pp. 12-13.

indicate the state of agriculture today. Two-thirds of the nation's gross domestic product is derived from farming. Over ninety percent of all exports are products of the land. Three-fifths of the cultivated area of the country is managed for subsistence, the estimate of the 1960 subsistence crop being about £ 40 million; the remaining two-fifths of the farmland produced about £ 50 million worth of crops for the market. Most of the cash crops at present are exported, but as towns and export crop areas grown, the internal market for local produce is bound to expand. Today, coffee and cotton are the two most important cash crops in Uganda, together constituting on the average over 80% of Uganda's export income yearly. Both crops are widely grown throughout the southern part of the country and to some extent in the north. In addition, substantial earnings are also made from groundnuts, sugar, sisal, tobacco, and tea. According to McMaster[1] the chief crops grown for internal consumption, including cash crops grown for local markets and produce grown for home use by the grower, are sorghum, finger millet, cassava, and banana, including, presumably, plantain. In addition, a wide variety of

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[1]David Newcombe McMaster, "A Subsistence Crop of Uganda" (Ph. D. thesis, University of London, 1958), map no. 27.

other vegetables and fruits are grown, especially about the cities and towns. These include yams, pineapples, potatoes, and beans.

Coffee

Robusta coffee covered 498,000 acres in Uganda, in 1960, and returned £ 12.1 million to producers. Of this, over 93 percent was grown on small holdings. The other seven percent was grown on estates.[1] At present crude methods of processing the fruit limit the quality of the product. Processing for quality of product is the major problem of coffee production today. The International Bank for Reconstruction and Development[2] has stated the problem quite clearly: "It is of the utmost importance that quality be improved.... It is our belief that competition in the world coffee market is so keen that buyers who might have bought on price alone are now becoming extremely quality conscious. Furthermore, we believe that, unless the quality of coffee is improved, revenues to growers will fall substantially." And again, "The problem of improving the quality of most Ugandan coffee comences at the first stage of processing the bean."

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[1] International Bank for Reconstruction and Development, <u>The Economic Development of Uganda</u> (Entebbe: Government Printer, 1961), p. 127.

[2] <u>Ibid.</u>, p. 129.

As a native to Uganda in the wild state, Coffea robusta is ecologically well suited to the country. It does not appear to suffer substantially from epedemics of disease or insect infestation. Evidence indicates that quantity of production may be directly related to the total rainfall during the dry season months of December, January, and February.[1] Robusta is not, however, entirely free of insect attack, the most important pests being lace bug and Antestia, both of which are bugs which feed on vegetative growth.

Pest control is a matter of some concern with the more valuable arabica coffee. Significant pests are root mealy bug, lace bug, Antestia, and the fruit-borer, Stephanoderes (a biting ant), as well as a rust fungus of leaves, Hemileia vastatrix. Spraying with high potency contact poisons, such as aldrin and dieldrin, is the usual method of controlling the insects, and copper sulfate is used against Hemileia. The extent to which insects, especially Antestia, reduce yields in arabica is not clear, but in some localities, at least, the influence may be substrantial, as indicated by the following entry in the Annual Report of the Department of Agriculture[2]

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[1]Uganda Department of Agriculture, Annual Report of the Department of Agriculture for the Year Ending 31st Dec. 1961 (Entebbe: Government Printer, 1962), p. 127.

[2]Uganda Department of Agriculture, Annual Report of the Department of Agruculture for the Year Ending 31st Dec. 1960 (Entebbe: Government Printer, 1961), p. 9.

for 1960, in reference to three districts in the Western Province where arabica has only lately been introduced: "Whilst it is difficult to assess precisely the benefits of spraying in terms of increased yield, farmers generally are impressed by the effects and as a result there has been a revival of interest in Arabica coffee in the three districts."

Cotton

Uganda cotton is a long-staple, high quality cotton, most of which is exported, with some sold internally for cloth manufacture and cottonseed oil production. The chief insect pests are a bug, Lygus, which feeds on flowers and fruits, and the spiny bollworm, Earias. Earias is exceptionally destructive at times, as larvae feed on the growing points, eating small fruiting points and ruining embryonic leaves. Because a single growing point cannot sustain a growing larva throughout a season, the larvae wander over the plants, destroying one growing point after another.[1] According to the International Bank for Reconstruction and Development[2] overall cotton production

[1]Uganda Department of Agriculture, Annual Report of the Department of Agriculture for the Year Ending 31st Dec. 1958 (Entebbe: Government Printer, 1959), p. 34.

[2]International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), pp. 133-134.

can be increased by about 30 percent by controlling insect pests. Current cotton yields average between 300 and 450 pounds per acre. In some cases increases of from 200 to 480 pounds per acre have been achieved by spraying schedules designed to control *Lygus* and *Earias*. DDT has been found to be most effective in controlling these insects, and attempts are now under way to induce farmers to spray. The problem is largely in convincing them that the investment in sprays, pumps, and labor will be more than offset by returns from greater production. Peasant farmers, who grow most of the cotton, have in most cases neither the educational background nor the financial resources to understand and undertake the spraying program on their own for the initial years.

Cattle

The practice of cattle raising in Uganda had its origins, apparently, in Nilo-Hamitic nomads who drifted southward from northern deserts into Uganda at some unknown time in the past. Cultural traditions and patterns of behavior associated with nomadic pastoralism therefore tend to dominate the cattle-herding tribes today. Primarily their cattle are maintained as a symbol of personal wealth; specifically, bride-prices must be paid in cattle. As the movements of these people are becoming increasingly restricted through development and land settlement, overgrazing of the land is becoming more and more a problem. This is particularly true of the Karamoja District of extreme northeast Uganda.

Though livestock are widely raised in the northern part of the country, this is largely for personal wealth, according to tribal tradition. The Baganda, of the south, also own cattle and goats, and as they are not a pastoral people, they hire neighboring Bahima tribesmen to tend them. Because the practical-minded Baganda use shillings rather than living animals as a measure of wealth, these animals and their hides readily find their way to the market.

Unfortunately, all of Uganda's cattle, including those owned by the Baganda, are of the tough, long-horned Ankole type, or the equally tough, hump-shouldered Zebu type, breeds which have been herded over the scrub and grass-lands of East Africa fro many centuries. These breeds are resilient, able to survive well under dry conditions, and fairly resistant to effects of ectoparasitism, but they grow slowly, are low in milk productivity, and produce inferior cuts of meat. On the other hand, modern breeds of dairy and beef cattle have not become established in Uganda, because of a combination of cost of importing and establishing herds of good stock, and the widespread occurrence of trypanosomiasis, ticks, bovine pleuropneumonia, rinderpest, and other diseases. There are at present some 650,000 to 700,000 cattle in Karamoja, and some of these are sold to the Jinja and Kampala markets. Disease, especially rinderpest, anthrax, and bovine pleuropneumonia, require closely controlled immunization and quarantine measures.[1] Greatly expanded veterinary services are needed for Karamoja, but even with such services, progress will undoubtedly be slow because of the inherently conservative nature of nomadic cattle cultures.

Nagana

Unfortunately, large areas of Uganda which could otherwise be excellent grazing land are infested with tsetse fly, *Glossina spp*. These areas include the extreme north, bordering on the Sudan, essentially the whole western side of the country, except where dense forests exist, and a sizeable area of southeastern Uganda. Substantial areas of the northern plains and the central portion of the country around Lake Kyoga have been cleared of *G. pallidipes* and *G. morsitans*, two savannah species.[2] The problem of clearing areas of tsetse is a difficult one. Extensive spraying operations are

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[1] International Bank for Reconstruction and Development, *The Economic Development of Uganda* (Entebbe: Government Printer, 1961), p. 180.

[2] *Ibid.*, p. 172.

unselective and leave dangerous residues. This is not perhaps serious during the initial stages of clearing when humans and stock are not occupying an area. Once the land has been settled, however, such methods become a hazard, especially since failure to keep the land free of tsetse will almost certainly result in a return of the pest. Phillips[1] has discussed the complexity of habitat manipulation in controlling Glossina. There are several species which carry both human and animal trypanosomes. Each species has its own ecological requirements, although the total ranges appear to overlap considerably. Speciation in Glossina, therefore, appears to be ecological rather than geographical. Herein lies the problem. Alteration of the habitat to discourage one species may only encourage another. According to Phillips, encouraging vegetative growth to reduce light intensity and heat and increase humidity on the ground level so as to discourage *G. swynnertoni* and *G. morsitans* (savannah species) tends at the same time to encourage forest species, such as *G. pallideps*, *G. brevipalpis*, and *G. palpalis*. One the other hand to reduce cover and increase light, temperature, and evaporation rate may have deleterious effects on the soil. It must be

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[1]John Phillips, *Agriculture and Ecology in Africa* (New York: Frederick A. Praeger, 1960), pp. 63-65.

emphasized here that carrying capacity in tropical lands diminishes drastically when soils are exposed to sun and heavy rains. Twenty-one species of Glossina are recognized in East Africa, each with its own adaptations to particular vegetation communities. In general, movements of adult flies are controlled by light, heat, air humidity, wind, and evaporation, as well as the vegetation. The pupae are affected by soild conditions, such as drainage, texture, and temperature. The role of vegetation as both result and determinant of these conditions is obvious.

Turning to the trypanosomes themselves, Trypanosoma brucei is a parasite of wild ungulates and is transmitted by Glossina to domestic stock in which it produces the disease negana. T. Brucei apparently has little effect upon native wild mammals, but the effect on domestic stock, which are of exotic origin, is debilitating. For this and other reasons, a novel suggestion has been made that more use be made of native animals as a source of meat. Huxley[1] states that on lands with a carrying capacity of one cow per 30 acres, wild game can yield four pounds of meat per acre, as compared to three by deomestic stock. Uganda, according to Huxley, is considering ways to domesticate the eland and perhaps the buffalo.

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[1] Julian S. Huxley, The Conservation of Wild Life and Natural Habitats in Central and East Africa (Paris: UNESCO, 1961), p. 37.

Petrides and Swank[1] suggest that "game ranching would seem to be especially worthy of serious thought as a source of high protein food in areas of protein deficiencies. Since game animals are immune to the trypanosomiasis that affects domestic stock, costs of tsetse bush-clearance often may be avoided." One might raise doubts about saving costs of tsetse control, as human trypanosomes, though scarce, are also carried by Uganda tsetse flies. Increasing human activities in tsetse fly areas can be expected to increase the likelihood of sleeping sickness outbreaks.

Extension

Because of the low efficiency of peasant farming, it has been suggested that this type of farming be replaced by plantations. Sir Andrew Cohen[2] rejects this view on the grounds that Africands tend to resist land alienation, and that despite its inefficiency peasant farming distributes the wealth widely among the people and promotes economic and political stability. He holds that a comparatively small increase in peasant farming efficiency would

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[1] George A. Petrides and Wendell G. Swank, "Management of the Big Game Resources in Uganda, East Africa," Trans. 23rd North American Wildlife Conf. (Washington: Wildlife Management Institute, 1958), pp. 461-477.

[2] Sir Andrew Cohen, British Policy in Changing Africa (Evanston: Northwestern University Press, 1959), pp. 94-95.

produce substantial improvements in wealth. "The task," he says, "is essentially one for agricultural and veterinary field or extension services, for farm institutes and agricultural teaching in the schools. The need is to persuade the farmers to cultivate in the right way, to take the correct measures against disease, to organize their farming operations properly." We can see in this perhaps three objectives: the training of agricultural research scientists; the training of a corps of extension personnel to interpret scientific developments to the farming people and encourage them to improve their farming methods; and the general education of the farm population to equip them with a knowledge of underlying principles so that they can understand the newer discoveries and recommended techniques brought to them by the extension workers. One particular difficulty lies in the way. In general, farming as a business enterprise lacks appeal. Young people associate farming with austere living conditions and plain hard work breaking the hard red soil with simple hand tools. It is "the old way" of life. Many with totally insufficient training drift to the cities in search of employment already much too scarce. Those with a modicum of education aspire to such occupations as clerk, typist, or other white collar jobs. There are, of course, some highly enterprising and prosperous farmers, especially among the Baganda, but altogether too few. To become educated is viewed as a way to abandon farming and emulate the European expatriate civil servant who, by African standards, is comfortably well off. Farming is thus too often left to the old and the ignorant, and as a result, the educational level of those on the land is generally low.

In spite of this, farming must still remain the rock foundation of the nations economy, and therefore it can only be assumed, for better or worse, that if the government's intentions of providing eight years (now reduced to seven) of universal education[1] be realized, then the general educational level of the farm population will rise accordingly, thus making the farmers more receptive to extension teaching and more capable of implementing technical knowledge on their lands. It is hoped that the financial success of some farmers will contribute to a changing attitude among ambitious young men.

The organization of the extension service is essentially as follows: a senior agricultural officer administers the service. Within each region there is an agricultural officer responsible for a staff of field

[1] Reporter (Nairobi), Dec. 23, 1961, p. 24.

workers. This staff consists of one assistant agricultural officer per county, assisted by several agricultural assistants. The assistant agricultural officer is responsible for direct field contact with farmers.

The International Bank for Reconstruction and Development[1] states that the first class of students with the B. Sc. in agriculture graduated from Makerere in 1961, and that those graduates are qualified for immediate appointment as agricultural officers in the Department of Agriculture. Because, however, Makerere serves all of East Africa, it was estimated that eight would be available to Uganda. This same source recommends the establishment of nine additional agricultural officer posts. In addition, in 1961, all existing posts were filled by expatriates, and it was recommended that these posts be Africanized as quickly as possible. On the other hand, twelve assistant agricultural officers were on leave in 1961 for further studies in order to qualify for up-grading to agricultural officer.[2] This in turn only serves to aggravate an existing shortage of assistant

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[1]International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), pp. 106-108.

[2]Uganda Department of Agriculture, Annual Report of the Department of Agriculture for the Year Ending 31st Dec. 1961 (Entebbe: Government Printer, 1962), p. 37.

agricultural officers. Though an average of one per county is approved, the shortage is acute, because of insufficient candidates at the farm institutes at Bukalasa and Arapai, where they begin their training. At present a successful two-year training program at one of the institutes qualifies a candidate for agricultural assistant. Particularly promising students may continue with an additional two years of training at Bukalasa for a diploma which qualifies them for appointment as assistant agricultural officer. The farm institutes, which in addition serve as experiment stations, provide a training in fundamentals of agricultural practice and scientific principles on which they are based. In addition, the four-year diploma course includes a full year of practical field training in modern agricultural methods.[1] Admission to the farm institutes is based on successful completion of secondary school with Cambridge School Certificate. Evidently, a farm institute diploma serves for admission to university work for pruposes of up-grading to agricultural officer. An expansion of cash crop farming will necessarily increase the demand for extension services and personnel.

[1]Uganda Department of Agriculture, Annual Report of the Department of Agriculture for the Year Ending 31st Dec. 1960 (Entebbe: Government Printer, 1961), pp. 17-18.

Significance for Education

A knowledge of basic elements of agronomy and plant nutrition is a must for farmers anywhere, and certainly no less so in a tropical country, where soils are easily ruined for productive purposes. Ugandan farmers, whatever their level of formal education, must quickly come to an awareness of mineral nutrients and of soil textures, structures, and microorganisms. They must have some understanding of the nature and functions of roots, stems, and leaves. The classical taxonomy- and morphology-oriented botany has always been useful to our own agricultural economy in the past, and would seem to be so for the people of Uganda at present. Although modern biochemistry and organic chemistry will be useful tools for the agricultural research worker at the experimental centers and the university, such knowledge would be of limited practical value for most people.

Intensive cultivation of crops naturally invites insect pests, and as farming improves and expands insects can be expected to become increasingly important, especially as attempts are made to raise production and improve the quality of crops. Therefore, insect morphology and taxonomy are important knowledge for the general population. Vague terms, like "mdudu" (insect or pest), will have to be replaced by specific standard common names for specific insects of agricultural importance, and the nature of their feeding methods and modes of reproduction will have to be learned.

It is the present author's prognosis that the educational level of the northern cattle tribes will remain discouragingly low for a long time, partly because of the inherent difficulties in providing schooling for widely scattered and semi-nomadic peoples, and partly because of the highly conservative nature of these tribes. Nevertheless, in order to avoid overgrazing as the land available to them becomes progressively more restricted, they will have to become aware of the importance of limiting herd sizes. From the standpoint of a biology syllabus, this means a knowledge of soils. It also means a knowledge of the interdependence of organisms. An introduction to biotic communities with special reference to the equatorial grassland biome would provide useful background to prepare them for the inevitable pressure from the government agencies to reduce the sizes of their herds, so as to raise the quality. It is strongly urged here that certain aspects of earth science, such as climate and weather and soil study, be integrated into a biology curriculum at an early stage for these people. Further, a knowledge of the principle of parasitism, together with specific information on some of the diseases of cattle, and an introduction to animal nutrition are regarded by the present author as essential knowledge for the progress of cattle husbandry.

Plant and animal breeding are in their infancy in East Africa; one taste of a local orange or grapefruit strongly suggests further studies in this area. Badly needed are new breeds of live stock which will combine the toughness and durability of the Ankole and Zebu with some of the finer qualities of European stock. Basic elements of Mendelian genetics at the secondary level might help interest promising young students in becoming research workers in this area.

CHAPTER IV

PUBLIC HEALTH IN UGANDA

"Masses of historical evidence illustrate the fact that in communities where such conditions as malaria, hockworm, and deficiency diseases are rampant, human output is at a minimum." --- National Academy of Sciences-National Research Council.

Dietary Problems

Malnutrition does not appear to be a serious problem in Uganda, with the exception of Kwashiorkor, a syndrome produced basically by a protein-deficient diet and aggravated by a low calorie intake. The syndrome includes edema; loss of melanin in skin and hair, resulting in a characteristic coppery color; apathetic and peevish behavior; distended abdomen; and ultimately death. According to the International Bank for Reconstruction and Development,[1] the disease is "one of ignorance, since vegetable protein in the form of groundnuts, peas, beans and cereals, and animal protein in the form of flying ants, grasshoppers, eggs or fish, are usually available to the mother, and dried skim milk can either

[1]International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), p. 299.

be obtained free or purchased at a price that most families can afford to pay." Infants in Uganda are usually weaned abruptly at the age of a year and, being unable to chew the tough native goat or beef, are fed a diet consisting exclusively or almost exclusively of matoke, a paste made of the boiled fruit of the plantain, *Musa paradisiaca*. The paste is rich in starch, but deficient in lipids, proteins, and nutrients. Apart from this one disorder which can be corrected through education, the people of Uganda appear to have adequate diets. Famines, such as are found in some parts of the world, donot occur here, partly because of the uniform climate and dependability of food production, and partly because of the moderately low population density.

Malaria

Probably the most serious disease of Uganda is malaria. The International Bank for Reconstruction and Development[1] reports that there were 120,214 cases of this disease in 1955, and that this rose steadily to 180,021 in 1959. This rise is due in part to a general population rise. Nevertheless, the total number afflicted with the

[1] International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), p. 298.

disease is not declining. Taking 6.451 million persons as a population figure,[1] the incidence of malaria in that year appears as approximately 2.8%. This does not include those individuals (conceivably quite a few) who, because of ignorance, lack of clear-cut symptoms, or remoteness, do not request medical assistance, yet suffer prolonged illness of varying degree of severity and are unable to contribute to the general prosperity of the country. Such persons would further tend to add to the total reservoir of the parasite.

The common causative agent of malaria in East Africa is <u>Plasmodium falciparum</u>. It differs from <u>P. vivax</u>, the common species in most parts of the world, by a longer asexual cycle (48 hours), a lesser stimulation of the immune response, and a delayed appearance of the gametocytes, or infective cells.[2] The chills and fever, which are cyclic in other forms of malaria, are often irregular in occurrence, and cases appear to vary greatly in severity. Prolonged morbidity is therefore common. During a school visitation safari through Tanganyika, the

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[1]Uganda Ministry of Economic Development, Statistics Branch, <u>Uganda Census, 1959: African Population</u> (Cyclostyle (Entebbe: The Ministry, 1961)), pp. 24-25.

[2]G. Macdonald, "Epidemiological Basis of Malaria Control," <u>WHO Bulletin</u>, 15 (1956), 613-626.

present author was told by an American teacher near Morogoro that at his school the commonest cause of absenteeism was malaria. The attacks of the disease did not appear to be serious, and would last several days at a time, after which the child would return to school to resume his studies.

The occurrence of malaria in the whole of equatorial Africa has been viewed with great concern by the World Health Organization of the United Nations, and that malaria control on the continent is one of that organization's most important projects can be seen by the great number of reports on the subject in its periodicals. However, the importance of malaria as a cause of morbidity and loss of per capital productivity is probably far greater than its importance as a cause of death. The National Academy of Sciences-National Research Council[1] states that contrary to widespread belief, malaria is probably not the major killer of children, and that malaria needs to be controlled not so much because of its lethality as because of the "African's reaction to the disease itself." The Council's report does not specify what that reaction is, but presumably it is simply the experience

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[1]National Academy of Sciences-National Research Council, Recommendations for Strengthening Science and Technology in Selected Areas South of the Sahara (Washington, 1959), pp. 22-23.

of extreme illness and the desire to be free of it.

Attempts to control malaria take two forms: suppressive drugs taken as a preventative, and chemical spraying to destroy the mosquito vector species, _Anopheles gambiae_ and _A. funestus_. Drug therapy is limited in effectiveness for several reasons. First, of course, is the cost. Too few African families at present can afford to buy these drugs regularly, and irregular use of the drugs is not effective. Second, even if these drugs could be supplied free to the whole population (a costly undertaking), it is doubtful if many of the Africans would take the care to use the drugs, partly because preventive medicine by its nature does not produce striking and therefore convincing improvements in personal well-being. Indeed, there may even be good practical reasons for not suppressing the parasites. Some of the seasoned British personnel prefer to get a "good" case and have it cured than to have a suppressed case for an extended period, for a drug-suppressed case cannot always be diagnosed readily, even by blood examination. A neighbor of the author in Kampala, a Scotswoman, suffered severe headaches, anemia, and general lack of vitality for four years before it was discovered that she had suppressed malaria, and then only after repeated blood examinations. A third limitation on the effectiveness of drug suppressants is the tendency of the protozoans to develop resistant strains. Proguanil-resistant strains of P. falciparum and P. vivax have been found in Southeast Asia, pyrimethamine-resistant strains of P. falciparum and P. malariae have been found in Kenya, Tanganyika, and West Africa, and in Colombia and Thailand strains of P. falciparum have been found which were resistant to chloroquine, amodiaquine, and hydroxychloroquine simultaneously.[1] The above source, indicates, however, that drug resistance has not been a serious problem in practice. Nevertheless, the appearance of drug-resistant strains in several parts of the world and among several species of Plasmodium indicates rather widespread genetic capacities for such developments.

Mosquito control through poisoning is at present the most widespread method of malaria control, and probably will remain so for a long time. Despite occasional resistance, behavior changes following sublethal dosages, and other local technical problems, it is by far the most effective method at present available to malaria control teams. The development of a number of high potency organophosphorus and chlorinated hydrocarbon poisons since World War II has provided a powerful weapon in the

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[1]World Health Organization, "Problems of Malaria Eradication in Africa," WHO Chronicle, XVII, 10 (Oct., 1963), p. 375.

war against mosquitoes. Nevertheless, a more comprehensive approach to mosquito control will eventually have to be developed, for while poison resistance has not so far interfered with eradication programs generally, it is a growing phenomenon. The World Health Organization has already pointed to the fact that of the world's principal anopheline vectors of malaria, nine species are resistant to dieldrin, one to DDT, and six to both poisons simultaneously.[1]

There are numerous other problems which, though small, tend together to reduce the effectiveness of chemical sprays in many parts of equatorial Africa. DDT, for example, is not only poisonous to mosquitoes, but irritating as well. Anopheles gambiae frequently tends to avoid DDT-covered surfaces in homes and thus often makes less than fatal contact with the poison. In addition, treated houses may be replastered soon after spraying, or entire houses may be missed in a spraying campaign.[2] Further, as populations of humans and domestic stock continue to grow, the danger of their being poisoned by these chemicals will tend to increase.

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[1]World Health Organization, "Problems of Malaria Eradication in Africa," WHO Chronicle, XVII, 10 (Oct., 1963), p. 375.

[2]Ibid., p. 371.

To date methods of biological control of malaria-carrying mosquitoes have not been developed to a useful extent, though possibilities along this line do exist. There are two fairly obvious reasons for this. First, there are chemical companies which have the available capital and facilities to carry out the necessary research for a product which will be useful and at the same time profitable for themselves; comparable corporation resources do not exist for the development of biological control products; therefore, chemical spray methods have led the way. Second, biological control methods are often far more complex in principle and in application; therefore, far more lengthy and time-consuming research must be carried out under field conditions.

There are several possible approaches to the biological control of anopheline vectors. One is to manipulate physical aspects of the habitats so as to provide unsuitable environmental conditions for one or another stage, usually larval or pupal, of the life cycle. One immediately thinks, of course, of the traditional draining of swamps and marshes, which has proved so generally unsatisfactory since ancient Roman engineers tried to drain the Pontine Marshes. Such projects are very costly, and have profound and often unpredictable results. Our own experience with the Everglades and the prairie potholes indicates what undesirable effects on soils result from such tampering with large ecosystems. The delicate nature of tropical soils obviously precludes this kind of operation on large scale.

A second approach is to manipulate biological aspects of the habitat through introduction of appropriate predatory or parasitic species. This approach, too, is fraught with hazards. The introduction of the mongoose into the Caribbean Islands, the American grey squirrel into Britain, the European starling into North America, and rabbits into Australia are all examples of the enormity of error which can occur in transplanting species into areas where they have never been a part of the biotic communities. Nevertheless, thorough scientific investigation into the ecology, physiology, and behavior of possible parasites and predators ought to reveal a few suitable control species. Indeed, one predator already has shown promise. While visiting a school near Kisumu, Kenya, the author had occasion to visit a biology class field trip to a nearby pond. There, among native ngege, or Tilapia, and other indigenous fauna, were schools of Gambusia affinis, our own native American mosquito-fish, milling around the upper levels of the water near the shore, just as the author had so often seen them in the ditches and swamps of Florida and the

Okefenokee. Rosen[1] says that this little fish, which can consume unbelievable quantities of mosquito larvae and pupae, has been introduced into every tropical country in the world and has been successful in controlling malaria in at least a few places.

Attempts have been made in New Zealand to develop a method of mosquito control using parasitic fungi of the genus Coelomyces. The present limitation lies in the lack of a suitable artificial culture medium for the fungus. The World Health Organization is supporting research at the University of Bristol to develop a method of culturing this fungus in sufficient quantities for control programs.[2]

Still a third approach to vector control is the manipulation of the biology of the organism itself, or to put it another way, the manipulation of the genetic environment of the organism. Control of the screw-worm fly of our own Great Plains was achieved through mass releases of sterilized males. Matings between sterilized males and wild females resulted in "crop failures" of the fly the following year. A somewhat different

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[1]Donn E. Rosen, "It Makes a Career of Eating Mosquitoes," Aquarium Journal, XXIX, 1 (Steinhart Aquarium, Jan., 1958).

[2]World Health Organization, "Biological Control of Arthropod Vectors," WHO Chronicle, XVII, 11 (Nov., 1963), p. 432.

variation is the mass rearing of strains bearing recessive lethal genes. Males bearing these genes can then be released to swamp the wild populations. The advantage of genetic manipulation lies, of course, in its harmlessness to humans, live stock, and wildlife. The prospect of raising and releasing a sufficient number of mosquitoes for release into the sprawling lake and marsh country of central Uganda, is, of course, formidable at the very least. Yet, with the aid of a statistician to compute the number of specimen needed to reduce viability sufficiently in a given population of mosquitoes in a given area, there is no reason why it could not be done.

Rather than to think of chemical sprays and biological controls as alternative methods of control, it would be wiser to think of them as complementary, and as integral parts of a complex program, using many techniques and methods, and founded upon many principles drawn from a thorough understanding of the ecological aspects of the disease. This has been recognized by the World Health Organization:[1] "There is therefore a growing realization that control measures should be fitted into the eco-system of the vector rather than imposed upon it, and, hence, that every vector control programme should be

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[1]World Health Organization, "Ecology and the Biological Control of Vectors," WHO Chronicle, XVIII, 2 (Feb., 1964), p. 41.

preceded by a thorough assessment of the ecological situation." This, the Organization goes on to say, would enable control agencies to take advantage of environmental factors which naturally limit the numbers of the vectors, while at the same time providing information on which to apply the correct sprays at the right times and places. Obviously, what is being pointed to here is a need for a new science of vector control, built around a comprehensive study of the total biology of the species involved.

Yellow Fever

Though yellow fever is not at present a problem in Uganda, there is evidence that it could become a problem at any time. Mahaffy[1] gives a brief account of the history of epidemiological studies of yellow fever. Following the discovery in South America that there were two epidemiological forms of the disease, an urban human-to-human pattern with Aedes aegypti as the vector, and a sylvan pattern in which some kind of wild animal formed the chief reservoir of the disease which was transmitted sporadically to rural villages, the next major discoveries were made in Africa. In 1927 it was discovered in West Africa that rhesus monkeys were highly susceptible to

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[1] A. F. Mahaffy, "The Yellow Fever Situation in Africa," Bull. World Health Organization, 11 (1954), 319-324.

yellow fever, and that the causative agent was a virus. The basic ecological principles of sylvan yellow fever as it exists in Africa were then worked out in the forests of Bwamba County in western Uganda.

On December 19, 1961, the writer was invited, as a guest of Mr. Eric Lucas, of the Institute of Education at Makerere University College, to attend a field trip to Zika Forest, near Entebbe, under the auspices of the East African Natural History Society. The field trip leader was Dr. A. J. Haddow, of the Virus Research Institute, and who was engaged in further research on the ecology of yellow fever. According to the notes entered in this writer's journal for that evening, it is believed that yellow fever was originally endemic in the monkey population of equatorial forests of Africa, including at least the red-tailed monkey, Cercopithecus nictitans. Because the forest is dark, considerably more so than the surrounding landscape, it is an efficient radiating body. Distinct thermal layers develop over the forest at night, and insects move upward through the forest at differential rates. Many species pass through the canopy into the overlying thermal strata, and are then carried by wind to other forest areas. During certain hours of the night Aedes simpsoni and A. africanus come into contact with the monkeys in the canopy, where they feed on their blood, in this way spreading the yellow fever virus. As humans began clearing the forest edge and planting crops, the monkeys descended at evening to the ground to raid the gardens. Aedes aegypti, a ground-dwelling mosquito of the forest edge, picked up the virus from the monkeys and transmitted it to humans. Having in this way broken out of the forest, the virus then spread via humans and Aedes aegypti to all parts of the tropical world. The two routes of distributing yellow fever would tend to make the disease a very difficult one to control. Fortunately, however, an effective vaccine has been developed. Nevertheless, the continued possibility of outbreak and the findings of yellow fever studies in Africa illustrate the importance of knowledge in depth of the ecology of vectors and causative organisms in epidemiology.

Filariids

A multitude of apalling things are carried by blood- and lymph-feeding dipterans, not the least of which are filariid worms. Many genera of these roundworms inhabit the subcutaneous and other regions of various mammals. Of these, Onchocerca volvulus infects man via an obnoxious biting fly, Simulium damnosum. According to Hyman[1]

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[1]Libbie Henrietta Hyman, The Invertebrates: Acanthocephala, Aschelminthes, and Entoprocata, Vol. III (New York: McGraw-Hill Book Co., 1951), p. 379.

the larvae, or microfilariae, appear to be attracted to the site during biting by the salivary secretions of the fly, which then ingests them. She does not elaborate on the life cycle in this case, but presumably it is similar in major respects to that of Wuchereria bancrofti, a confamilial species, the life cycle of which is at present the best known of the group. If so, the microfilariae undergo several changes within the fly before being transmitted as young adults to the skin of another human, at which time they penetrate, probably through the wound made by the biting fly. These worms invade the subcutaneous and connective tissues, initiating inflammation, resulting eventually in the formation of fibrous nodules and tumors, within which are the adult worms and their microfilariae. The microfilariae are not blood-borne, but travel under the skin.

Simulium is a black fly the larvae of which inhabit fast-moving water. Though the literature examined by the author does not mention this fly or associated onchocerciasis, Wilks[1] indicates its importance locally: "10 years ago the biting fly Simulium damnosum, the vector of onchocerciasis, was so abundant along the Nile near Jinja, that the area was populated by only 7000 persons. A successful program to eradicate the fly was conducted,

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[1]Norman E. Wilks, personal communication (1963).

and 75,000 people are now prospering in the region." The implications of this disease for settlement and development of selected areas are obvious.

Several other filariid worms parasitize man in tropical Africa. These are generally minor in Uganda, perhaps the most spectacular being the mosquito-borne Wuchereria bancrofti, which blocks the lymph vessels and produces tremendous swellings known as elephantiasis. On occasion one may see such a fictim walking the streets of Kampala, but the disease does not appear to be common enough to be regarded as a serous public health problem at present.

Hookworm

The most common soil-transmitted worm in Uganda is Ancyclostoma duodenale, the hookworm, of which Wilks[1] has this to say: "It is the most prevalent helminth infecting the populace. No survey conducted during my studies has revealed less than 70% infection rate." The International Bank for Reconstruction and Development[2] reports 10,120 cases of hookworm disease (infection serious enough to

[1]Norman E. Wilks, personal communication (1963).

[2]International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), p. 298.

cause specific recognizable symptoms of illness) in 1959, and this figure corresponds closely to those of the previous five years. Beaver[1] provides some important figures on the reproductive capacity and viability of hookworm: the average stool from a person containing a single pair of adult worms could contain as many as 50,000 eggs. "It has been shown that a damp cotton pad about 16 cm. in diameter can pick up nearly 25,000 hookworm larvae in a few minutes from a spot where faeces containing only 50,000 eggs were deposited six days earlier." Adults may live as long as fifteen years in the intestine, and infective stages remain viable for several weeks in the soil. Hyman[2] considers hookworms to be the most injurious parasites of man.

Control of hookworm is not likely to be achieved through treatment with antihelmintics, partly because of the lack of effective safe drugs at the present[3] and partly because of the probability of reinfection. The best that can be done along this line is to use what

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[1]Paul C. Beaver, Control of Soil-transmitted Helminths ("Public Health Papers," No. 10 [Geneva: World Health Organization, 1961]), p. 27.

[2]Libbie Henrietta Hyman, The Invertebrates: Acanthocephala, Aschelminthes, and Entoprosta, Vol. III (New York: McGraw-Hill Book Co., 1951), p. 339.

[3]Paul C. Beaver, op. cit., pp. 20-21.

drugs are available to relieve severe cases when they come to the attention of medical personnel. Interruption of transmission might be achieved either by isolation of the eggs and infective stages in latrines or other sanitary devices, or by altering soil conditions where they are likely to occur so as to produce an unsuitable habitat. According to Beaver[1] control programs have not to date paid sufficient attention to the ecology of the parasites: "In view of the failure of conventional measures and the rather precise conditions known to be required for incubation and preservation of infective stages in the soil,... it would seem that the most promising approach to control of transmission may be through the application of ecological principles." Beaver is of the opinion that sanitary measures usually recommended to tropical peoples are not readily adopted for many practical reasons. Shoes are too expensive to be worn in wet places; defecation by small children near the houses cannot be controlled under existing culture patterns and economic levels; latrines are often offensive. But the details of soil-conditioning to destroy eggs or infective larvae in rural Africa have yet to be worked out. Changing long-established customs is always

[1]Paul C. Beaver, Control of Soil-transmitted Helminths ("Public Health Papers," No. 10 [Geneva: World Health Organization, 1961]), p. 27.

difficult, and unless the population readily understands the underlying principles of hookworm infection and at the same time can experience definite improvements in physical well-being or quality of living in some other way, the customs will not change at all. Hookworm, therefore, will resist medical treatment through dispensaries and sanitary education programs, but will disappear with a general rise in education and monetary income, and the accompanying change in style of living. This is not to say that the problem should be ignored in the hope that it will go away by itself. Indeed, an awareness of the nature of hookworm infection and its consequences may act as a source of motivation and a desire for a materially better life.

Schistosomiasis

The last of the parasitic helminths to be considered here is *Bilharzia* (formerly *Schistosoma*), causative agent of schistosomiasis. Incidence of this disease has remained relatively constant over the last five years, the International Bank for Reconstruction and Development[1] reporting 1,614 cases in 1959, though in some

[1] International Bank for Reconstruction and Development, *The Economic Development of Uganda* (Entebbe: Government Printer, 1961), p. 298.

years the figure has exceeded 2,000. To a large extent infection is unavoidable where it occurs, because of the necessity of entering the margins of waterways to obtain water or fish. Despite the stability of the figure for incidence, there is evidence that in fact it was once rare in Uganda and has been increasing over a longer period. Blair[1] states that in 1939 schistosomiasis was widely but thinly distributed, but by 1945 the occurrence of Bilharzia mansoni was serious in the West Nile District and that a survey in that year showed all of the people to be infected in one West Nile county. It has since increased in importance throughout Uganda. Most cases probably do not come to the attention of the medical personnel because of the lack of severe, acute symptoms. Long periods of reduced vitality result, and with infections of this sort it is impossible to estimate the degree and extent of lowered resistance to other diseases. Little is known of the biology of the vector snail of Bilharzia. Attempts at snail eradication by copper sulfate or sodium pentachlorophenate sprays have not shown much promise, except in Southern Rhodesia.[2] The same source indicates that baboons in

[1] D. M. Blair, "Bilharzia Survey in British Africa," WHO Bulletin, 15 (1956), 205-273.

[2] National Academy of Sciences-National Research Council, Recommendations for Strengthening Science and Technology in Selected Areas South of the Sahara (Washington, 1959), pp. 30-31.

Kenya have been found to harbour Bilharzia where they live near infected humans; sanitation, therefore, cannot alone be depended on to eradicate the disease, even if it were feasible to achieve. The problem is a complex one with no feasible solution in sight. The National Academy of Sciences-National Research Council recommends a broad-based attack on the problem by ecologists, aquatic biologists, malacologists, protozoologists, toxicologists, sanitary engineers, and medical practitioners.

Venereal Diseases

Second in importance to Malaria in terms of reported incidence is gonorrhea. According to the International Bank for Reconstruction and Development,[1] 21,645 persons were treated in 1955, and this rose to 38,714 in 1959. During this period, the report points out, there was an increase in availability of medical treatment services throughout the country, and the rise in incidence may be due merely to the fact that more people were able to get to dispensaries. In addition, the percent of the population infected with venereal diseases may not be so high as these figures indicate, because many of the reported

[1]International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), p. 298.

cases are repeated infections in the same individuals. But the fact that syphilis has steadily declined from 19,975 to 9,267 during this same period is somewhat confusing, as the epidemiology for both diseases is the same. The International Bank Report suggests that antibiotic-resistant strains of Gonococcus may have developed.

Control of these diseases depends on continued medical treatment at present, with changed social mores as a long-term ideal. Venereal disease, therefore, is a sociological problem as much as a biological one, though the masses of the people ought to be familiar with the biological nature of the disease. The decline of tribal ties and discipline and the movement of large numbers of young people to the urban centers in search of salaried employment tends to intensify the problem; venereal diseases will therefore probably persist for a long time as a serious public health problem.

Endemic Diseases

Endemic diseases mentioned by the International Bank Report as bearing watching are schistosomiasis, trypanosomiasis, and typhoid fever. While the incidence of each of these is low, the wide distribution of these diseases and the growing human population densities in certain centers provides opportunities for possible future epedemics. Human trypanosomiasis in East Africa is caused by Trypanosoma rhodesiense, carried by several species of tsetse flies. The areas where sleeping sickness is most likely to occur are also the areas where trypanosomiasis of cattle also occurs. As a result, human populations have not settled such areas in any great densities. As the population of Uganda increases, however, demand for land will result in attempts to reclaim tsetse fly country for settlement. The problems of tsetse fly control are dealt with in the chapter on agriculture.

Causes of Death in Sweden

A comparison of the pattern of disease in Uganda with causes of death in Sweden (selected as a representative highly developed European nation) will give some picture of the state of health of the Ugandan population. According to the Statistical Annual of Sweden,[1] the commonest causes of death in Sweden were diseases of the circulatory system (29,109), most of which (21,719) were arteriosclerosis and degenerative heart diseases. About half as many deaths (14,431) were due to neoplasms,

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[1] "Causes of Death in 1961," Statistical Annual of Sweden, as quoted in correspondence from Swedish Information Service, New York.

mostly cancer (12,622). Diseases of the nervous system and sense organs accounted for over 10,635 deaths. By contrast all infectious and parasitic diseases together took the lives of 748 persons, the most severe being tuberculosis (504). It is interesting to note that suicides alone accounted for over a thousand deaths.

We would naturally expect fewer parasitic diseases in Sweden, even apart from the consideration of technological development, just because of climate alone, as many parasites, such as hookworm, yellow fever virus, and plasmodia either are killed directly by the cold of winter, or have their transmission cycles broken by inactivity of the vectors. Nevertheless, the fact that out of 73,555 deaths in Sweden in 1961, 43540, or well over half, were caused by circulatory diseases and neoplasms indicates the large percentage of people who are living out the fullest biological extent of their lives within the range of present scientific knowledge, whereas the International Bank Report for Uganda does not even mention cancer and cardiac diseases. Apparently not enough people in Uganda reach the age at which degenerative diseases become important. Of course, there is a bias here: awareness. Older generations of Africans are less likely to make use of medical facilities for routine examinations, and many simply die "of old age" without actually having been aware of specific degenerative disorders. Nevertheless, the complete absence of these diseases from the Report's discussion of medical problems in Uganda and the absence of these diseases from the Report's list of diseases are compelling evidence of the high toll of parasitic and infectious diseases in early and middle years. It may well be also that many persons beyond the middle years die from secondary effects and complications of many years of being hosts to invading microorganisms.

Medical Personnel

If independence is to have full meaning, Uganda must now looc to solving its public health problems through native-born personnel. At present most of the physicians and medical research scientists are expatriates. There is in addition a severe shortage of auxiliary medical personnel as well, such as nurses, technicians, and laboratory and field assistants. Some indication of the situation can be seen in figures presented by the World Health Organization[1] for supply of doctors for several parts of the world. Most European countries have one

[1]World Health Organization, "Changing Trends in the World Health Situation," WHO Chronicle, XVII, 7 (July, 1963), pp. 254-255.

qualified doctor per 900 persons. Argentina has one per 770, and the United States has one per 710. The most poorly staffed Central American republics, El Salvador and the Dominican Republic, have one per 5000, as has also India. Figures for African countries show Ghana with one per 21,000, Nigeria with one per 33,000, and the former French Congo with one per 14,000. Though figures are not available for Uganda, we may assume that its supply is similar to that of Ghana and Nigeria.

According to the National Academy of Sciences-National Research Council,[1] Makerere University College is able to accept all qualified candidates for full professional training in medicine, and further "the planned expansion of training facilities could be expected to take care of the demands of the three territories over the next ten years." Whether "the demands" refers to medical needs of the nations or the pressure of applicants is not clear. Educators in East Africa recognize a bottleneck in education at the secondary school level, and it may be that the ability of Makerere to accomodate all qualified applicants for medical training simply means that the supply of secondary school graduates is

[1]National Academy of Sciences-National Research Council, Recommendations for Strengthening Science and Technology in Selected Areas South of the Sahara (Washington, 1959), p. 41.

inadequate. At any rate, it is clear that the supply of doctors, nurses, and supporting personnel constitutes an educational problem of primary urgency for Uganda.

Implications for Education

The high incidence of parasitic diseases leaves no doubt as to the importance of an understanding of the principle of parasitism at all levels of education among the population. Life cycles of specific parasites of outstanding importance, such as hookworm, *Bilharzia*, and *Plasmodium*, should be learned. The natural history, including life cycles, of disease vectors, such as anopheline mosquitoes and tsetse flies, should also be included.

Another matter of importance is that of nutrition. The fact that ignorance, rather than food production, is a major deterrent to good nutrition indicates that the fundamentals of nutrition should occupy a prominent place in a unit on human physiology.

With an understanding of the nature of infectious disease and of dietary disease, not only would the people of Uganda be better prepared to seek and understand medical treatment, but also they could be expected to accept and use preventive medicine more widely than at present.

The scarcity of physicians being as great as it is, the masses of people will for a long time depend for services on contact with ancillary medical personnel, such as nurses and dispensary technicians. The importance of this technician-level contact becomes even more apparent when it is realized that many of the physicians are still expatriates, whereas nurses and medical assistants are local people who speak the tribal dialect and with whom, therefore, the patients can be expected to communicate freely. Such personnel, as integrated members of the communities, will be useful loci for diffusion of knowledge.

CHAPTER V

FORESTRY, PARKS, AND WILDLIFE

"The wildlife of today is not ours to dispose of as we please. We have it in trust. We must account for it to those who come after." -- H. M. King George VI. Inscription over entrance to Nairobi Royal National Park.

Forest Resources

Luxuriant tropical forsets exist along the southern and western fringes of Uganda, as well as on the higher elevations of Mt. Elgon in the east. However, the total amount of forest land is only about 6,000 square miles, or 6.5% of the total land area. Of this, somewhat over 2,000 square miles produce saw-timber.[1] Much of the rest is inaccessible. Uganda produced for export a mere 300 cubic meters of saw-logs and no other wood products in 1958, and in 1959 no wood exports were recorded.[2] The forest resources of Uganda, therefore, are obviously severely limited, and although sound forest practice is important to Uganda's forest land, not only for its

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[1] International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), p. 202.

[2] Food and Agriculture Organization of the United Nations, Yearbook of Forest Products (Rome: FAO, 1960), p. 78.

small amount of food production, but also in order to protect watersheds and soils, wood resources will contribute little of consequence to the nation's economy.

Although a few of the native hardwoods are of commercial use, such as Mt. Elgon olive, which is used in the manufacture of furniture, a more widespread use of native wood products consists of fuel and poles for local consumption. Some Eucalyptus has been planted for posts and poles, and pines and cypresses have been introduced for softwood purposes. A forest tree nursery for these exotic species exists near Kampala. With the building of more roads, more of the native forests will become accessible and can be upgraded by management for improvement of quality of stock and stand. On the other hand, some of these forests will always be unavailable for timber production because of their location on steep mountain slopes and in national parks. Perhaps the best way to look at Uganda's forest produce is from the standpoint of serving local needs so as to reduce wood imports.

Wildlife Resources

Uganda shares in no small way in the wildlife resources for which East Africa is justly famous. Early British workers in East African game conservation were men of rare character. They had the rough and hardy spirit of the settlers, yet that fine sense of aesthetic appreciation which is the mark of intellectuals. It was not easy to convince a distant government of the need for increased funds to protect lions which raided the settlers' live stock and ate railroad workers on the Uganda Railway; or truculent and stupid great rhinos which charged everything within smelling distance, including railroad locomotives; or elephants which terrorized native villages by night. And when the British government gradually realized the high importance of game preserves and national parks, the Africans remained understandably unconvinced. Their crops and livestock were in constant jeopardy and the antelopes and other vegetarians were a traditional source of food to many tribes. The advent of World War II did not help. Britain at war was in no position to spend large sums of money to protect leopards and hyaenas in distant Africa, and hunting safaris and tourists were simply not abroad during those years to provide direct revenues. That wildlife has declined rapidly in recent years has been amply documented. "everyone, including myself, who was in East Africa a mere thirty years ago, can testify to the striking diminution of its large wild life since then."[1]

The disappearance of Africa's wild animals would be a tragic loss of a great source of interest and pleasure. On the Eurasian continent populations of man increased slowly but relentlessly over many centuries as civilizations emerged. Gradually the primeval habitats and their creatures disappeared, but so slowly as not to be noticeable within one generation or even five. It is difficult to know what to regret in the loss of the wild conditions, since no one can remember what the wild conditions were, except in a few fringe areas, such as parts of Siberia and the Himalayas. Certainly, wild Europe is gone and has been for a long time. In North America, white men brought an advanced technology with which to wreak destruction to an extent they could never themselves have predicted. But in the time they have been here, especially since the beginning of the Industrial Revolution, destruction of wild areas and their inhabitants has progressed at such a rate as to be witnessed with awe by recent generations. Noticeable changes take place within any one person's lifetime,

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[1]Julian Huxley, The Conservation of Wild Life and Natural Habitats in Central and East Africa (Paris: UNESCO, 1961), p. 15.

and one has only to read the journals of Audubon and others of his time to realize the magnitude of that change within a century and a half. We know what to regret, and we are feverishly trying to preserve what is left. The history of the two northern continents can contribute much to an understanding of the problem of conservation in Africa, where there is yet much to preserve. The destruction of habitats and game is proceeding rapidly, but has not gone quite so far as in North America. We cannot, of course, preserve the whole of Africa in a wild state, nor should we; yet development for cities and agriculture is not out of harmony with preservation of samples of that vast treasury of wild creatures with which man has evolved to his present state in the last million years. Africa is the earth's last continent on which large primeval herds of mamals still commonly exist. The wild vegetarians and associated large predators, such as leopards and lions, are our closest approximation to the earth's Pleistocene faunal communities.

Elephants

Uganda's wildlife is rich and varied, though in general large ungulate herds such as are known in the Serengeti Plains of Tanganyika and parts of Kenya do not constitute a dominant element in its fauna. The great elephant herds whose ivory once brought Uganda its fame are still a reality. On a trip into Murchison Falls National Park with his family in August on 1962, the present writer encountered a herd of about two hundred. This was no fleeting guess, as portions of the herd crossed and re-crossed the road, holding up passage of the car for an hour and a half. Elephants today are restricted to the two national parks and the slopes of the Ruwenzori. In both national parks they appear to be thriving under protection, and the Ruwenzori are essentially inaccessible at the present. Elephants are highly adaptable, and can survive well in a variety of habitats--bamboo, veldt, forest, or savannah.

Rhinoceros

In contrast to elephants, rhinoceroses are singularly unadaptable, and perhaps obsolescent as a group. Two species occur in Africa, the black rhinoceros, Diceros bicornis, and the white rhinoceros, Ceratotherium simum. Both species are represented in Uganda. In the last half century both species have suffered heavily throughout their ranges. Grzimek[1] estimates about 2,000 white

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[1]Bernhard Grzimek, No Room for Wild Animals, trans. R. H. Stevens (New York: W. W. Norton and Co., 1957), pp. 102-104.

rhinoceroses in all of Africa, some of them in South Africa, but a fair share distributed between the Congo, the Sudan, and Uganda. Political instability in the Congo and public and governmental apathy in the Sudan toward conservation leaves Uganda in the position of being the only hope at present of saving the Central African white rhinoceros. The original range of the white rhinoceros in Uganda included only the West Nile District, being limited in eastward distribution, apparently, by inability to cross the Albert Nile.[1] A few, however, have been introduced into Murchison Falls National Park in order to establish a population under protection.

The black rhinoceros, Diceros bicornis, seems so far to have survived somewhat better than the white, possibly because of its greater original range, which was continuous over most of East Africa. In Uganda it is at present found in Karamoja, Acholi, and (a few) Lango. Its westward distribution is impeded by rivers, as it is not known to have crossed the Nile into Bunyoro from Lango and Acholi, nor crossed the Kagera into Ankole from Tanganyika, where it is common.[2] The

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[1] R. M. Bere, The Wild Mammals of Uganda (London: Longmans Green and Co., 1962), p. 76.

[2] Ibid., p. 75.

species is well represented in the northern part of Murchison Falls National Park.

Although neither species suffers from natural predation, the reproductive capacity is too low in both cases to tolerate heavy human depredations. Bere[1] gives the following information for the black rhino: "The gestation period is twelve or thirteen months and rhinos breed every three years or so. Only one calf is born at a time; it reaches maturity in six or seven years." Yet depredations are common over many parts of East Africa. With the decline of rhinoceroses in India and Southeast Asia, African rhinos have become a source of rhinoceros horn, which is ground to powder and sold in India and China, where it is believed to be an aphrodisiac (hardly needed there even if it were true). A local conservationist in Nairobi once told Alan Moorehead that rhino horn sells for £ 4 per pound in Mombasa, and that the two horns from a good mature specimen might weigh ten pounds.[2] Most of the rhinoceros poaching for horn probably takes place in Kenya and Tanganyika; to what extent poaching for horn occurs in

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[1] R. M. Bere, <u>The Wild Mammals of Uganda</u> (London: Longmans Green and Co., 1962), p. 75.

[2] Alan Moorehead, <u>No Room in the Ark</u> (New York: Harper and Bros., 1957), pp. 111-112.

Uganda is not clear. More often illegal hunting of rhino is probably to drive them off grazing land or for meat. Nevertheless, rhino are fast disappearing in Kenya, and horn hunting can be expected to exert its influence in Uganda soon if it has not already done so. Both black and white rhinoceroses badly need protection in Uganda, and this need will become intensified as settlement of new land takes place and as the nation's human population increases.

Hippopotamus

In contrast to rhinoceroses, hippopotamus populations are burgeoning, at least in the national parks. This is especially true in Queen Elizabeth. Overgrazing has resulted in severe erosion and deterioration of range flora for themselves and other herbivorous species. In an investigation of the hippopotamus problem in Queen Elizabeth National Park, Petrides and Swank[1] found that in one study area there were seven elephants, ten buffaloes, eight waterbucks, seven wart hogs, 1.5 Uganda kob, 1.3 bushbucks, and over 40 hippos to the square mile. They further found that an adult hippopotamus, weighing

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[1] George A. Petrides and Wendell G. Swank, "Management of the Big Game Resources in Uganda, East Africa," Trans. 23rd North American Wildlife Conf. (Washington: Wildlife Management Institute, 1958), pp. 461-477.

between 2500 and 4000 pounds, would eat over 400 pounds of grasses in a night's grazing. They reported that in many places in the park grass communities were degraded, and even annual weeds were struggling to survive. "Thorn scrub was invading the grasslands. Much bare ground was evident. Dust storms occurred with each high wind. Gullies up to 50 feet deep were eroded in some slopes and advancing uphill at rates of over 50 feet per year." One must actually observe these animals first hand in order to grasp the efficiency with which these animals consume ("encompass" is a more appropriate word) their food. One night in Murchison Falls National Park, the author was attracted to the window of the lodge by the approach of a steady grinding sound. Looking out into the night, the writer saw dimly a huge form resembling a petroleum storage tank moving slowly past the window. Soon it turned around and passed in the opposite direction. Never once did the grinding or the movement stop; the hippopotamus, like some great machine, methodically moved up and down the length of the grassy area behind the lodge, never stopping to rest, constantly grinding up food in the largest mouth of any animal on earth.

Research is at present under way to develop a process by which hippopotamus meat can be processed for export without refrigeration. Such a process, if perfected, would provide a means of making the harvesting of excess hippos profitable. A small local industry could thus be supported.

Other Wildlife

Other game animals found in the two existing national parks are wart hog, forest hog, buffalo, lion, leopard, spotted hyaena, Nile crocodile, giraffe, and a number of antelopes including, among others, Uganda kob, defassa waterbuck, bushbuck, sitatunga, Jackson's hartebeest, cribi. Most of them are in satisfactory state under protection, though the number of giraffe is small (a few hundred in Murchison Falls National Park, northern section). Zebra, giraffe, common eland, roan antelope, beisa oryx, dikdik are among the animals found in Karamoja; most of these are not under protection in the parks. In addition, a few mountain gorillas are known in the Kigezi District, and Schweinfurth's chimpanzee is found in a few forest areas of Queen Elizabeth National Park.[1]

Protection of any kind of animal life means protection of the whole habitat in which the species lives. A complete

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[1] R. M. Bere, The Wild Mammals of Uganda (London: Longmans Green and Co., 1962), pp. 25-27.

ecological study therefore is needed for each species needing further protection at the moment, and a biological study ought to be made of each major region of the country, so as to determine the most promising reserve areas and to map whatever seasonal movement may take place among important herds. The government has already recognized the need for a national park in Karamoja and has taken steps to set land aside, plan development of a lodge, and plan a road to the park area from the nearest urban center at Soroti, which in turn is connected by a fine paved highway to other urban centers in the country. Huxley[1] has recommended that "the boundaries to the Queen Elizabeth National Park be redefined so as to include as much as possible of the Ruwenzori massif." Expansion of the parks system into Kigezi, West Nile, Mt. Elgon, and other parts of Uganda for the protection of other floral and faunal communities is not yet contemplated.

National Parks

Two developed national parks at present exist in Uganda, and a third, as previously mentioned, is in the

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[1]Julian Huxley, The Conservation of Wild Life and Natural Habitats in Central and East Africa (Paris: UNESCO, 1961), p. 109.

planning and development stage for Karamoja. Queen Elizabeth, in Toro, just south of the Ruwenzori, includes the lands around Lake George and the Uganda side of Lake Edward. Forests and savannah predominate, though a prairie-like condition exists over the crater country in the northern section of the park. The total area of the park is 767 square miles, and features a safari lodge, motor tracks throughout much of the area, and regularly scheduled daily launch trips along Kazinga Channel joining the two lakes. Bird life abounds in the channel and on the lake shores, and buffalo, waterbuck, elephant, and hippopotami are abundant. Other kinds of wildlife, such as lions, leopards, wart hogs, forest hogs, bush pigs, and kob are present in sufficient numbers to provide a rich opportunity for an exciting tourist vacation.

Murchison Falls National Park, covering 1,100 square miles of savannah (and veldt?) lies in Bunyoro and Acholi, and is bisected by the lower Victoria Nile. It boasts the greatest herds of elephant in all of Africa, with tusks of superb size and prime quality. Historic Murchison Falls lies in the park and can be approached either by automobile from above, or by launch from the Nile's famous crocodile-infested waters below (a worthy trip for the photography-minded tourist). Paraa Lodge overlooking the Nile, provides a splendid view of this great river, and hippopotami, lions, and leopards are known to frequent the lodge area at night.

Tourist Income

The importance of the tourist trade to Uganda should not be overlooked. Because of its climate, scenery, wildlife, and hospitality, it is an ideal tourist country. Travel and accomodation costs are within the country low, and service is polite and efficient. The tourist industry benefits Uganda by providing support for local business as well as a source of foreign money. Uganda is at present little known, yet by 1960 "about 7,500 visitors arrived in East Africa with Uganda as their first stop and an additional unknown number visited Kenya and Tanganyika first."[1] By that year Uganda was receiving about one-half million pounds annually in foreign tourist money. Mathews,[2] speaking for all of East Africa, believes that "about 80% of the 60,000 visitors East Africa now obtains come because of the wild life, and

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[1]International Bank for Reconstruction and Development, The Economic Development of Uganda (Entebbe: Government Printer, 1961), p. 236.

[2]D. O. Mathews, "Some Economic Aspects of National Parks and Reserves in Relation to Tourism" (Panel Paper Section 2(b), First World Conference on National Parks, Seattle, 1962, sponsored by the International Union for the Conservation of Nature and Natural Resources), p. 2.

if this were to go, then it would be impossible to maintain our present tourist income, which might drop by as much as £ 6 million per annum." A survey of visitors departing from East Africa, based on a 65% sample taken during 1959 and 1960 showed an average length of stay of 20 days, of which an average of 10% was spent in Uganda. Further, it was found that the average visitor spent £ 120 during his 20-day stay, and that Uganda received an average of £670,000 per annum in tourist income during those two years.[1]

Personnel

Personnel concerned with the protection of game are divided between two agencies, the Uganda National Parks and Game Section of the Game and Fisheries Department. The first agency, of course, is directly responsible for protecting and maintenance of the parks, and the second with controlling illegal hunting throughout the country, scientific studies of the game resources, protection of animals in the game reserves, and regulation of licensed hunting.

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[1] D. O. Mathews, "Some Economic Aspects of National Parks and Reserves in Relation to Tourism" (Panel Paper Section 2(b), First World Conference on National Parks, Seattle, 1962, sponsored by the International Union for the Conservation of Nature and Natural Resources), pp. 6-7.

In the national parks there are three categories of personnel: warden, cadet warden, and ranger. Practical field knowledge through life in the outdoors is the only qualification for a ranger; Cambridge School Certificate is required for cadet warden; and three years' experience as cadet warden plus a one-year diploma course in wildlife conservation overseas qualifies a candidate for up-grading to warden. The United Nations Food and Agriculture Organization plans to open a one-year in-service course for rangers at Arusha, Tanganyika. As of August, 1962, there were three cadet warden posts available, of which one had been filled.[1]

The term "ranger" as used by the Game and Fisheries Department refers to a supervisory position, and requires some formal education. Subordinate to the game ranger are assistant game rangers, game assistants, and game guards. Each game ranger is responsible for an area almost as big as a province, and consequently must travel considerably. Despite the small size of the staff, it has been difficult to recruit personnel for the assistant game ranger post in particular, because "Africans who have achieved any reasonable degree of education, as well as having the necessary integrity, sense of discipline

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[1]Col. C. D. Trimmer, personal conversation (1962).

and power of command, do not, generally speaking, appear to be attracted to 'life in the bush'."[1]

African Attitudes

Some idea of the extent of illegal hunting can be gained by the following figures: fewer than 10,000 head of game are killed legally by resident and visiting hunters each year throughout East Africa; yet in Uganda alone over 250,000 head per year are killed illegally, chiefly by use of wire snares.[2] Part of this hunting is for ivory, part for meat. Originally, illegal hunting was chiefly a matter of traditional tribal meat hunts, and at first there was a tendency to be lenient on grounds that tribal tradition should be treated with tolerance. It is now clear, however, that much of the illegal hunting is highly organized. The waste is enormous, as many of the animals caught by snare are not recovered, but wander off to die slowly, often becoming highly dangerous in the meantime. Organized illegal hunts are

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[1] Uganda Game and Fisheries Department (Game Section), Report for 1 July, 1958 - 30 June, 1960 (Entebbe: Government Printer, 1960).

[2] D. O. Mathews, "Some Economic Aspects of National Parks and Reserves in Relation to Tourism," (Panel Paper Section 2(b), First World Conference on National Parks, Seattle, 1962, sponsored by the International Union for the Conservation of Nature and Natural Resources) p. 4.

common throughout the eastern part of the continent, and will probably remain so for some time, ivory being about the most lucrative game traffic in Uganda.

Popular African attitude toward the wildlife resources is changing. Among those with some education their value as a tourist attraction is being realized. A certain amount of national pride regarding national parks is developing in addition. Destruction to crops by wildlife is gradually becoming less of a problem; in fact in most of the well-developed farm areas today game animals have disappeared. Leopards are still wide-spread, but lions are now restricted to only a few areas, such as the parks. An attempt to further African interest in wildlife has been made at Queen Elizabeth National Park, where cottages for secondary school groups have been built on a scenic spot overlooking Kazinga Channel. Although many schools at present cannot afford transportation costs for their pupils, a few near the park have been able to do so. Interest in wildlife so engendered, however, is not lasting, as school pupils by and large have little enthusiasm for topics not directly leading to the school certificate examination.

Implications for Education

Because conservation is built upon a science of ecology, it is evident that a widespread general understanding of some basic principles of synecology is necessary if sound public policy with regard to wildlife resources is to have popular support. Further, much research needs to be undertaken in wildlife biology, and unless greater interest in wildlife is stimulated in secondary schools, it is going to be a low-prestige field. Some topics recommended here are the food chain; natural history of certain species of wildlife, such as buffalo, waterbuck, hippopotamus, and lion; parasites and diseases of wildlife, such as rinderpest; and descriptive range ecology, including types of grasslands (veldt, savannah, etc.) and forests, and the relationships of the animals to these broad habitat types.

CHAPTER VI

HISTORY AND CONTENT OF SYLLABI

Missionary Activities

Two phases can be recognized in the history of education in East Africa. No dates can be set clearly as to the change from one phase to the next, because the changes are not altogether clear-cut, and they occurred at different times in different places. These phases are not so much qualitatively different as they are different in emphasis. Too, they probably represent differences in outlook in the different generations and personal purposes of the educators at different times. However, each stage in the evolution of the educational system in East Africa changed the population and thus brought about changes in the recognized needs and aspirations of the people, and these in turn induced new developments in the educational system.

The first European education began with instruction in Christian religion by Roman Catholic and Anglican missionaries. This, of course, necessitated the ability to read, so that the Bible, religious tracts, and other paraphernalia of religious instruction could be read. The missionaries were the only teachers in Uganda from about 1877, when they first arrived, until 1924. It might have seemed that such education, carried on by limited personnel as merely part of their many and varied duties, and under such rude and primitive conditions, without equipment of any consequence, would have been scant basis for the sophisticated educational system found in Uganda today. Yet among preliterate peoples this must have been the only possible step. As Bishop Willis[1] has said, "For in these primitive schools there first stirred into life that desire for knowledge which made it impossible to stop at such a primitive form of education..."

But Christianity is not a mere abstraction existing *in vacuo*. It is an integral part of the whole fabric of western civilization. It was inevitable, therefore, that the new ethical teachings should necessarily demand changes in group and community patterns and behavior. The missionaries sought to bring about improvements in health, cleanliness, and hygiene, and to induce a high regard for diligence and manual labor, and to stabilize and improve their economy through improved techniques in agriculture and the mechanical arts. By 1924, there were about 2,000 schools, with an enrollment of 138,000 pupils.[2] Most of

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[1]Rt. Rev. J. J. Willis, "Some Aspects of Education in Uganda," *Some Aspects of Education in East Africa* ("University of London Institute of Education Studies and Reports," No. 9 (London: Oxford University Press, 1936)), p. 47.

[2]*Ibid.*, p. 48.

these were "bush" schools, where the very rudiments of primary instruction were carried out. In addition to the bush schools, the Church Missionary Society (Anglican) had a central day-school in each rural deanery, better staffed and equipped, and where English was introduced as a part of an upper elementary, or intermediate, sequence. A total of 17,000 pupils attended the C.M.S. central schools. Fees were charged to encourage regular attendance. One boarding-school at the same level also existed in each language area, for those who could afford it. The system was completed by a few three-year secondary schools. "As the best from each bush school passed on into the central or boarding-schools, so the best from these schools passed on to a secondary school for a final three years' course."[1] Roman Catholic schools followed a similar pattern. We can see in this not only the conditions for the first phase of East African education, consisting of poor, rural, conversion-oriented mission-schools, but also an elaboration into a progressive sequence of articulated levels, copying, perhpas only half consciously, the English system of education.

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[1]Rt. Rev. J. J. Willis, "Some Aspects of Education in Uganda," Some Aspects of Education in East Africa ("University of London Institute of Education Studies and Reports," No. 9 (London: Oxford University Press, 1936)), p. 48.

Early Modern Education

By the 1920's there arose the problem of financing. The growth of mission schools had reached a point where the burden of further expansion would become excessive, and the Administration was called upon to assume responsibility for fiscal assistance. At this time also the matter of suitable syllabi arose. In 1922 the Phelps Stokes Fund published a report of its African Education Commission, headed by Thomas Jesse Jones, based on a study of the needs of African education made in British dependencies in West, South, and Central Africa. Two years later, with the help of additional funds, a second report was issued, covering an extension of the study to East Africa. Basically, what the Commission's reports had to say was that African education ought to be community-oriented, rather than a copy of English school education, and that the syllabus ought to be adapted to the immediate needs of the people: "The adaptation of education to the needs of the people is urged as a first requisite of school activities. Much of the indifference and even opposition to education in Africa is due to the failure to adapt school work to African conditions."[1] An emphasis

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[1]Thomas Jesse Jones, Education in Africa: Report of the African Education Commission (New York: Phelps Stokes Fund, 1922), pp. 11-12.

on the agricultural, mechanical, and domestic arts was recommended, along with social studies. Specifically, it was recommended that the following topics be included in all secondary school syllabi: sciences; physiology; hygiene and sanitation; social studies; history; mathematics; languages; gardening and rural economics; mechanical and household arts.[1]

A somewhat similar point of view was expressed by Julian Huxley following a visit to East Africa on recommendation of the Advisory Committee on Native Education in Tropical Africa.[2] Huxley started from the premises that man is an organism living in communities; that activities are related to environment and perpetuated through traditions; that education is necessary to continuation of traditions and improvement of communities. "Education, therefore, must be adapted to community life and the needs of particular communities in particular environments." He held further that the curriculum ought to be organized around a core of central ideas to which subjects could be added in a structured relationship with the core. Not surprisingly, he recommended biology

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[1]Thomas Jesse Jones, Education in Africa: Report of the African Education Commission (New York: Phelps Stokes Fund, 1922), pp. 66-68.

[2]Julian Huxley, "A Biological Approach to Education in East Africa," Oversea Education, II, 1 (Oct., 1930), pp. 1-13.

as the core subject for East African schools on the ground that on agriculture and public health depended the future well-being of East Africa.

Conditions were set for experimentation at this time, it would seem. The school system was expanding; a new source of support, the government, was in sight; and new goals and purposes were beginning to be recognized for the educational system, specifically, enlightened citizenship and occupational skills. The emphasis was on the adaptation of the schools to the economics and social patterns of the people. Between 1930 and the end of the Second World War little or nothing appears to have been written about East African schools, or about the great experiment in adaptive education there. As the writings appear following the war we are made aware that whatever was said in the 1920's regarding education suitable for Africans, very little was actually accomplished in that direction. We find in the 1960's a system of organization and a syllabus patterned after English schools. There are minor modifications provided for overseas schools, but often these are inadequate. For example, secondary school biology pupils are expected to become familiar with selected species of trees in both summer and winter conditions, and then allows such trees as Pithecellobium and Jacaranda as substitutes for English elm, rather than eliminating the topic altogether. All secondary schools at present follow the syllabus for the Cambridge School Certificate and Higher School Certificate, and all students wishing to qualify for university entrance must take the Cambridge School Certificate and Higher School Certificate Examinations or the equivalent in General Certificate of Education.

One is at first inclined to be strongly critical of English educational administrators in East Africa for having failed to bring about the adaptation of education to what was in the 1920's so apparently Africa's need. But a further inquiry into the facts is in order. When the author placed his proposed study before an African colleague at Makerere for comments, he was told that this had been tried before (referring to the Phelps Stokes Fund report) and had been met with resistance. The author was told not to expect Africans to welcome changes from the English syllabus. Others have pointed to this in the literature. Elvin[1] found one reason for the Africans' reaction:

> Indeed, although "giving Africa an education adapted to the African" may have seemed to us when we began to use the phrase thirty years ago to represent an advance in our thinking, it has not always

[1]Lionel Elvin, Education and the End of Empire ("Studies in Education, University of London Institute of Education," No. 8 (London: Evans Bros., 1956)), pp. 18-19.

> been welcomed. Many Africans have felt that such an education must be a sort of second best... They know very well that over here the education that is most academic and least practical... continues to enjoy the greatest prestige. There comes a moment when even though we know that imitation English education is unlikely to be good education in Africa we cannot say so without being thought to offer less than our best.

The Present Pattern of Schooling

Until recently Uganda had a basic pattern of six years of primary schooling, two years of junior secondary schooling, four years of senior secondary, and two years of higher school (sixth form). Following independence in 1962, changes were made in the syllabus for the primary schools, with a resultant change in pattern. In 1964 the two-year junior secondary schools were absorbed into the primary schools and the sequence condensed into a total of seven years. A national primary school syllabus is designed to prepare pupils for enlightened citizenship and emphasizes civics, history, geography, English, science, and mathematics. Biological science emphasizes nature study and agriculture. Considerable attention is paid to insects, family welfare and health, and first-hand observations of natural habitats, animals, and plants. Successful completion of primary school leads to senior secondary school, admission to which is determined by performance on an external examination based on the national primary school syllabus. At the end of senior secondary school the candidates sit for the Cambridge School Certificate Examination or the Cambridge General Certificate of Education (Ordinary Level) Examination. A sufficiently good performance on School Certificate or the equivalent in G. C. E., Ordinary Level, qualifies a candidate for admission to higher school. Successful performance on the Cambridge Higher School Certificate Examination or the equivalent in G. C. E., Advanced Level, leads to admission to University studies.

School Enrollment, Teacher Supply, and Occupation

The illiteracy rate among adults in Uganda has been estimated by UNESCO[1] in 1952 at 70 to 75%. Though this figure is bound to have changed somewhat since that time, it indicates tolerably well the extent of the job of improving the nation's capacity to understand its problems. In 1959 the enrollment in primary schools was 337,578, or 34% of the nation's children of primary school age. In that same year only 16,848, or 6.2% of the children of the appropriate age group were in junior secondary school.

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[1]UNESCO, World Illiteracy at Mid-Century ("Monographs on Fundamental Education," No. 11 (Paris: UNESCO, 1953)), p. 38.

Senior secondary schools enrolled 3,412 or 0.7% of the children of the appropriate age range.[1] By 1962 the enrollment in primary schools was 399,500; for junior secondary it was 30,200; and for senior secondary the figure was 13,500.[2] Comparing percentage increase in enrollment for 1962 over 1961 with that for teachers for the same year, the figures are these: primary school enrollment rose by 3.5%, junior secondary by 16.1%, and senior secondary by 14.5%, while primary school teachers increased by 1.3%, junior secondary by 5.6%, and senior secondary by 17%.[3] It will be noticed that the great majority of people are getting no education at all or an inadequate amount; that the attrition rate is extremely high during primary school or at least between primary and junior secondary; that secondary schools are expanding more rapidly at present than primary; and that teacher supply increase in 1962 was not commensurate with pupil enrollment increase except at the senior secondary level. It must be pointed out, further, that the increase in

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[1]Ruth C. Sloan, "Uganda," The Educated African, compiled by Ruth Sloan Associates, ed. Helen Kitchen (New York: Frederick A. Praeger, 1962), p. 167.

[2]International Bureau of Education and UNESCO, International Yearbook of Education, XXV (Paris: UNESCO, 1963), p. 386.

[3]Ibid.

secondary school teachers is due to a considerable extent to a supply of expatriates. "Of the 776 teachers in service, barely thirty are African graduates. The others are qualified teachers from abroad or non-graduate teachers."[1] In 1961 Teachers College, Columbia University, sent its first contingent of about 150 American teachers and teacher trainees to East Africa to teach or prepare to teach in the secondary schools there, under a program sponsored by the International Cooperation Administration (now Agency for International Development). In 1962 about 150 more were sent, and since then, others have been sent each year, largely to replace those completing their tours of service. Very clearly, the supply of teachers at all levels needs to be greatly expanded, and this is certainly true of secondary school biology teachers.

Although the Ministry of Education has no data on the relation between years of schooling and occupational level, in general those who hold the School Certificate, or G. C. E. equivalent, enter the "middle stratum" of occupations.[2] In biology this means nurses, medical and veterinary assistants, agricultural assistants, and junior grade wildlife and parks personnel.

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[1] International Bureau of Education and UNESCO, International Yearbook of Education, XXV (Paris: UNESCO, 1963), p. 387.

[2] E. Okello, for the Permanent Secretary, Uganda Ministry of Education, official correspondence (1965).

The Present Biology Syllabus for Senior Secondary Schools

The currently used syllabus for biology in senior secondary schools is presented in detail in Appendix A. Certain adaptations are allowed for overseas centers. As examples, for the insects listed under section 3, certain tropical forms, such as tsetse fly and cotton stainer, may be substituted; general morphology, including leaf fall and flowering and fruiting cycles, of tropical trees, such as *Pithecellobium* or *Acacia*, may be substituted for summer and winter conditions of ash, beech, elm, etc. Apart from minor substitutions of this sort, there is no attempt at adapting the syllabus in any substantial way to the special needs of the tropical countries.

An examination of the present syllabus reveals certain serious omissions with respect to knowledge needed by the people of Uganda. Perhaps the most obvious of these is the study of serious parasites of humans and livestock. Considerable attention ought to be paid to their life cycles, epidemiology, and disease symptoms. Due consideration needs to be given to ecological aspects of control, and to life cycles of vectors.

Sufficient emphasis is not placed on soil minerals and the principle of fertility. While it is not necessary to make a detailed study of the role of all essential minerals elements, it would certainly be important to emphasize that soil fertility is defined in terms of available mineral nutrients, and that as crop plants remove natural supplies from the soil, they can be replenished by application of chemical fertilizers. The role of a few of the major nutrients should be studied as examples.

Completely absent is a section on Mendelian genetics. Pupils should have a knowledge of the concept of genes as units of heredity and of the fundamental laws of inheritance (chromosome number, dominance, and independent assortment). Popular acquarium fishes of the tropical fish trade are available in cities, such as Kampala, and schools can stock their laboratories with guppies or platies with which simple breeding programs can be carried out for demonstration purposes.

Though there is a section on ecology, the syllabus contains a revealing note: "A question on this section will always be set in the paper Biology I, but there will be a sufficient number of questions in the paper to allow candidates who have not had the opportunities of making observations in the countryside a good choice without answering the question on ecology." A greater emphasis needs to be placed on ecology as an important branch of biology, and this would include descriptive synecology.

Closely related to the subject of ecology is wildlife biology. It is widely recognized that school pupils have insufficient interest in or appreciation for the wildlife resources. Perhaps this can be explained in terms of syllabus. Africans aspire to the materially better European mode of life. Not only does the syllabus represent the means to greater earning power and the Europeanization of their private lives, but also its subject matter may be taken as a representative sample of what European civilization holds to be of value. If the syllabus contains no consideration for wild animals, while the older generations of Africans lived in constant and not always pleasant contact with them, perhaps the syllabus is inadvertently teaching that wildlife resources are to be discarded along with mud and wattle huts, malaria, and nakedness. Great national parks and wildlife reserves are not among the famous cultural resources of Europe.

A matter of practical concern for people in an essentially rural society with major problems of vector borne diseases, and in which agriculture plays a major part in the economy, is the ability to identify plants and insects. Introduction to the use of taxonomic keys and an understanding of elementary exonomic principles, important tools of modern field workers in biology, should be included as part of requisite training.

If much new material is added to the syllabus, then deletions of existing topics might be necessary. General discussions of the external features, life histories, and habits of a fish, a frog, a bird, and a small mammal can be excluded, along with development of a frog from egg through metamorphosis, without damaging the syllabus. Much of this can be relegated to the primary school level. General morphology, including leaf fall and flower and fruiting cycles of tropical trees (a substitute for characteristic features of trees in winter and summer) serves no useful purpose at secondary level and should be deleted. Some of the other material on which perhaps too much time is at present spent could be de-emphasized. Examples are tooth insertion and dentition, fruit and seed dispersal, and herbaceous perennials illustrating different types of storage organs and vegatative reproduction. Some of these items will probably find their way into other topics as incidental material. For example, storage organs in perennial plants might well appear in connection with translocation under the general topic of plant physiology.

It has recently been recognized by the Cambridge Local Examinations Syndicate that existing syllabi need modification for the tropical schools employing them. A new version of the School Certificate syllabus has been published, to be used in overseas schools beginning in 1966. Because the new version is to be employed in all overseas dependencies and new commonwealth countries, including India, Pakistan, Africa, the Caribbean, and Malaya, it is not specifically adapted to the needs of Uganda. The newer version contains essentially the same material as the current version which is designed for home use in Britain, but it is organized along a "principles" line. There is an expanded section on ecology, containing a study of succession in a cleared area in the school yard and studies of a number of communities, such as an old tree, a freshwater pond, and a crop plant with its associated organisms. Parasitism, genetics, and wildlife are, as at present, absent.

The Present Biology Syllabus for Higher Schools

Biology, zoology, and botany are offered as separate subjects in the sixth form. The syllabi will be treated separately. Since a very small percentage of pupils obtain places in higher school, but most of those pass on to university studies, higher school subjects can justifiably be considered a part of the university sequence of studies in the sense that the subject matter can be of a highly academic nature. This, however, does not rule out entirely some emphasis on matters of national concern. The present author takes the position that national needs should, in Uganda, be reflected in the higher school biological sciences syllabi, along with the more theoretical and purely academic aspects of biology. One of the functions of higher school should be to introduce students to, and interest them in, those areas of biology in which professionally trained men and research scientists are needed. Besides physicians, agricultural officers, etc., Uganda needs entomologists, ecologists, parasitologists, animal and plant pathologists, and practical geneticists. These are the personnel who will help find solutions to pressing problems in Uganda's development. A suitable syllabus might well be built around the subject of ecology. The author views the following topics as essential to a higher school biology syllabus: methods of habitat studies, photosynthesis and the carbon cycle, the nitrogen cycle, commensalism and internal parasitism, predation and external parasitism, population expansion and controls, Mendelian genetics and evolution, plant physiology, mammalian physiology, entomology, lower plants including fungi and bacteria.

Appendix B consists of the current higher school syllabus for biology. As at the senior secondary level, certain modifications have been allowed for overseas schools. These consist principally of permitting substitutions of species for study, such as Paramecium for Amoeba, tapeworm for *Hydra*, a toad for a frog; under the section on natural history, any two contrasting habitats may be used in place of the distinctly English habitats listed in the syllabus.

The present syllabus contains much that is good and useful, but the emphasis is entirely wrong. The classic comparison and contrast between a mammal and a flowering plant as representing the two branches of the biological world dominates the syllabus (a recommended 200 periods out of a total allowance of 350). One could well question the importance of dissecting and studying an earthworm. Parasites of importance appear in the present syllabus, but without sufficient thoroughness. Perennation is not really an important feature of equatorial plants, since there is insufficient difference between seasons. Similarly seasonal changes in secondary growth of woody plants lacks relevance in a country where the trees and shrubs grow continuously. There is totally insufficient time given to community biology.

As of 1967, a newer version of the syllabus for biology will be used in all overseas schools. The newer version represents a reorganization of the current syllabus under topics representing principles of biology. The substitutions allowed under the current syllabus are incorporated directly into the newer form. Content is not revised substantially, though the sections on genetics and ecology are enlarged. Genetics in the newer version will include polyploidy, chromosomal aberrations, and quantitative inheritance; ecology will concentrate on a thorough and comprehensive treatment of a single habitat, rather than the more superficial comparative treatment of two, as at present.

The Present Botany Syllabus for Higher Schools

No data are available to indicate whether students electing botany or zoology generally tend to go into the study of agriculture or medicine and veterinary medicine, respectively, at the university level. In the absence of such information, the author chooses to assume that higher school botany is usually elected by students having a special interest in it and will therefore likely pursue university studies in plant science or agriculture, whereas those electing zoology will more likely study medicine, veterinary medicine, or academic zoology.

Those aspects of botany, such as genetics, taxonomy, vascular plant physiology, and pathology, which are related to agriculture ought to occupy a prominent place in the syllabus. There ought, however, to be some material on woody plant anatomy and plant ecology for the benefit of those who may prepare for wildlife conservation or forestry. A course in botany, to be academically complete, should include some studies of lower plants (bacteria, cyanophytes, chlorophytes, seaweeds, and bryophytes), with attention to life cycles and alternation of generations. However, this latter material could well be covered in survey form, and details of complex life cycles, such as those of the Phaeophyta and Rhodophyta, can be passed over.

The present botany syllabus (Appendix C) allows, as do other syllabi, certain modifications for overseas schools, such as permitting local floras to be used, where available, in place of British floras for taxonomic studies; substitution of local forms of plant life for British forms in the syllabus constitutes the major portion of the adaptations. No new version of the botany syllabus has been put forth for use in tropical schools.

The emphasis which the present syllabus places on the physiology of flowering plants is useful for Uganda. The material on the cell needs to be brought up to date, including specific reference to nucleic acids. The material on plant pathology is weak, and although East African crops at present appear to suffer little from disease, a treatment in some detail of coffee leaf rust, Hemileia vastatrix, ought to be included because of its potential economic significance for the valuable arabica crop. Some attempt ought to be made, in adapting the syllabus to Uganda, to develop an appreciation for the nation's major habitat types (forest, veldt, savannah). The present syllabus contains a section on natural history and ecology, but fails to deal with the structure of habitats; for Uganda examples would be foliage and vegetation levels in the forest or the spatial relationships between trees and grasses on savannah and veldt in relation to water supply.

The Present Zoology Syllabus for Higher Schools

The current higher school syllabus (Appendix D) permits substitutions of local forms for British species listed in the syllabus for the benefit of overseas schools. As in other parts of this paper, the present writer would like to see more emphasis on ecology and interrelationships than the present syllabus shows. Such forms as the earthworm, a turbellarian, and Nereis, may be studied if there is time and room in the syllabus, but including a substantial series of such forms does not seem justified, especially in the light of the emphasis which needs to be placed on other matters. There is also too much emphasis on phyletic matters. Though it may be useful for a student to be able to recognize the phylum to which a specimen should be referred, there appears in this syllabus something of a preoccupation with classification, a condition which is probably inherited through tradition from Nineteenth Century Cuvierian zoology. Such matters as the food pyramid, carbon cycle, and population biology are more important. As mentioned previously, it is here supposed, in the absence of any evidence to the contrary, that students electing zoology in higher school have a special interest in the subject and are potential medical, veterinary, or zoology students at the university. This writer would therefore see a need for more emphasis on the cell and histoloty and experimental physiology. Much of the current material on protozoa is academic and of little use; the importance of trypanosomiasis, amoebic cysentery, and malaria in Africa demand attention to protozoans, but in a different context and with a different emphasis. The idea of a natural history study (section 3) is a good idea, as has been pointed out elsewhere, and the problem before us is to suggest suitable studies for native East African materials. Economic zoology ought to be made more imaginative by including topics on game ranching, the possible use of hippopotamus meat, rather than merely verbalizing on standard, and, for Uganda not altogether adequate, practices of domestic animal herding. Furthermore, there is, in reference to the problem of wildlife conservation, need to discuss the matter of reproductive potential and environmental resistance.

As of 1967, a new zoology syllabus for higher schools will go into effect in overseas schools. The new version brings cell biology up to date substantially, including mitochondria, DNA, RNA, enzymes, and the chemical nature of amino-acids and proteins. The account on respiration includes a discussion of the role of ATP. One of the most interesting features of the new version is the inclusion of an account of human evolution, a topic which, until a few years ago, was to be approached with due caution in East Africa, according to conversations this writer had there in 1961-62. The new version is a substantial improvement, but still omits some items, such as economics of wild animal populations mentioned above. Further, on parasitism, the newer version does not expect detailed treatment of important human parasites. The present writer considers detailed studies of the life cycles and ecology of several of these parasites and their vectors to be an essential training for potential public health physicians and research scientists.

CHAPTER VII

RECOMMENDATIONS

General Remarks

The syllabi following are proposed for use in senior secondary and higher schools in Uganda in place of those currently in use. It is expected that, if adopted, they will be subject to such revisions as experience proves necessary or desirable. In keeping with current practice in the use of the Cambridge syllabi, the following syllabi merely list topics to be covered, leaving it up to the individual teacher to determine the manner in which the material is to be organized and presented according to his own experience and point of view.

A Proposed Biology Syllabus for Senior Secondary Schools in Uganda

The following proposed syllabus is designed to provide basic knowledge for those who will likely serve as technical ancillary personnel in medicine, agriculture and veterinary services, and wildlife and parks, as well as to equip school certificate and G. C. E. holders with the knowledge of biological principles necessary to understand the problems and national policies in those areas of biology related to national development. The syllabus is, the author believes, sufficiently demanding and broad in scope to serve the academic needs of those who will be passing on to higher school.

Emphasis should be placed on careful observation and recording of results. Where experiments are carried out, pupils should report purpose, results, and conclusions. Natural history observations in field and laboratory should be recorded in the form of notes and careful drawings. Notes to teachers, marked with an asterisk (*), are included in the text to indicate the extent of details and to suggest and recommend activities and exercises.

1. Ecology and Wildlife Conservation:

(a) Biotic communities with special reference to Uganda: forest, steppe, veldt, savannah, bamboo, papyrus, marsh.

*Topic should be supplemented by field trips and photographs.

(b) Natural history of selected species of wild animals: two or three species common in the area where the school exists should be studied first-hand: various birds, lizards, or mammals should be studied intensively in the field with respect to food, feeding habits, daily activity rythms, habitat preferences, courtship and reproduction, care of young and dependency periods, enemies.

*Emphasis should be placed on field observation and recording of observed facts; stomach contents of collected specimen may be analyzed and skins examined for parasites.

(c) Adaptations of animals and plants to habitats.

*Observations should be made directly from nature: strangler fig, shape of fish, cockroach, walking stick, color of dead-leaf butterfly, toes of gecko.

(d) Predation, parasitism, disease: reference to lions, ticks, worms, rinderpest.

*Examples of predation can be seen on school grounds: lizards, spiders.

(e) Food chain.

(f) Limiting factors (food, water, mineral resources) and retarding factors (predation, disease) of production.

(g) National Parks and tourist trade: cultural and economic importance of parks.

*Parks or reserves should be visited if nearby; contact officials in advance for special arrangements for school groups; habitat requirements of animals should be emphasized.

(h) Natural history of hippopotamus: overpopulation and destruction of habitat.

*Value of controlled harvest to local economy should be discussed.

(i) Natural history of white rhinoceros; danger of extinction and attempts to save it.

*Compare with hippopotamus.

(j) Natural history of elephant; history of exploitation for ivory; problems of poaching; elephant as a tourist attraction.

*Current data on value of parks and tourism should be obtained from East African Tourist Travel Assn.

(k) Natural history of Chimpanzee and mountain gorilla; scarcity and limited distribution.

*It should be emphasized that Uganda is one of the very few countries in which these animals live.

2. The cell

(a) Structure and form of plant and animal cells: general features.

*Brief description of cell: cell wall, membrane, cytoplasm, nucleus; microscopic examination of living and stained plant and animal cells.

(b) Chromosomes and mitosis: brief outline of phases of mitosis.

*Examination of chromosomes in stained onion root tipp cells to see mitotic figures.

(c) Enzymes treated as chemicals which facilitate and control rates of chemical reactions in cells.

*Discussion should be brief and non-technical.

(d) Diffusion, osmosis, and turgor.

*Observation of plasmolysis of plant cells.

3. Survey of the plant and animal kingdoms by animal phyla and plant divisions.

*Descriptive treatment supplemented by observations of specimen; pupils should be able to recognize the major phyla and division.

4. Lower plants

(a) Bacteria.

*Observations of souring milk and other evidences of bacterial activity; reference to diseases caused by bacteria, such as bacillary dysentery and anthrax.

(b) Decay.

*Examination of decaying material in school garden or terrarium in laboratory.

(c) Bacterial diseases (e.g., leprosy, pneumonia, tetanus).

*Trip to a local dispensary or visit by local medical personnel recommended as a supplement; agar plate cultures of bacteria from soil or other sources, if feasible.

(d) Green algae: general features, walls, chloroplasts.

*Green algae can be cultured from local pond, swamp, or soil and examined under microscope; a variety of sources and forms should be used to show variety of forms and widespread distribution.

(e) Fungi and plant diseases: reference to fungous diseases of crop plants (rust fungus of coffee).
*Details of life cycles can be omitted, but reference should be made to spores as reproductive bodies; molds can be grown on moist bread or fruit and examined under the microscope; crop plant diseases should be observed where possible.

(f) Bryophytes and ferns: general features and conditions under which they grow; reproduction by spores.
*Where climatic conditions permit these should be grown around school grounds; details of life cycles are not necessary.

5. Soil study

(a) Formation of soil from parent material and decaying organic materials.
*Soil strata should be examined from cutaway slope.

(b) Textures and structure.

(c) Soil microorganisms.
*Microorganisms can be cultured by passing water through a column of soil.

(d) Carbon cycle and decay.

(e) Nitrogen cycle.

(f) Mineral nutrients and fertility: fertility defined as availability of essential minerals elements.

*Experiment with cuttings of Coleus grown in (1) de-mineralized water, (2) de-mineralized water passed through a column of soil, (3) de-mineralized water with a small amount of commercial fertilizer added, (4) Hoagland's solution (allow about a month for results).

(g) Mineral cycle.

*It is suggested that the relevance of mineral cycling to human nutrition be pointed out here.

6. Vascular plant morphology and taxonomy.

*When studying parts of food plants, opportunity to make reference to specific nutritional benefits should not be overlooked; a small vegetable garden containing plants of high nutritional value could be maintained by the teacher, and these plants could be used as specimen for study (bean, peanut, sweet potato).

(a) Roots: structure and function.

*Microscopic examination of root tip and cross-section of root.

(b) Stems: xylem and phloem.

*Microscopic examination of cross-section of herbaceous and woody stems.

(c) Leaves: Structure, form, arrangement, types of margins, etc.

*Microscopic examination of tissue layers, strip of lower epidermis showing guard cells; examination of a variety of living plants around school grounds.

(d) Flowers and pollination: parts of flower and arrangement; superior and inferior ovary; insect and wind pollination.

(e) Fruits and seeds: formation of fruits from ovary; kinds of fruits.

*Study of a legume as a representative fruit (bean, Cassia, Acacia); comparison with citrus and papaya.

(f) Seed germination and development.

*Direct observation of germinating bean seed; hypocotyl, epicotyl, cotyledons of bean as seen in dissection.

(g) Elements of classification of flowering plants: gymnosperms and angiosperms; monocots and dicots; salient features of selected angiosperm families, such as Leguminosae, Liliaceae-Amaryllidaceae, Convolvulaceae.

*Examination of specimen using hand-lens where necessary.

(h) Identification by keys.

*Use of simple dichotomous keys to identify some common plants (See Lind & Tallantire: Some Common Flowering Plants of Uganda. Oxford Univ. Press, 1962. Shs 18/30).

7. Vascular plant physiology.

(a) Soil-water relationships: Osmosis and turgor.

*Demonstration with collodion osmometer or similar apparatus.

(b) Tropisms: phototropism, geotropism.

*Pupils should perform their own experiments with germinating seeds and seedlings.

(c) Photosynthesis: raw materials and products; importance of the economy of nature.

*Benedict's test for sugar in leaves of amaryllid or lily, such as onion, Hemerocallis, or Agapanthus kept (1) in dark, (2) in light, respectively.

(d) Respiration: comparison with photosynthesis in terms of raw materials and products.

(e) Translocation and food storage.

*Test for sugar and starch (1) in onion bulb, (2) in sweet potato or yam; test for starch and sugar in various stems; relate to sections on plant morphology.

(f) Transpiration: refer to stomata; transpiration as a hazard to survival; a concomitant of opening of stomata for carbon dioxide.

*Use of cobalt chloride paper; examination of banana stem with hand-lens to see conducting vessels; demonstration of rise of ink or colored water through out plant stalk or stem.

(g) Plant nutrition: role of nitrogen, phosphorus, potassium, magnesium.

Coleus experiment (see 5(f)) can be adapted for this purpose by using mineral deficiency solutions.

8. Insect morphology and taxonomy.

(a) Anatomy.

*Dissection of grasshopper; observation of live cockroach.

(b) Life cycles: complete metamorphosis (beetle, ant, fly), gradual (grasshopper, bug).

*Specimen should be raised in laboratory.

(c) Mouthparts and feeding: reference to means of chemical control.

*Mouthparts to be observed by hand-lens (bug, grasshopper).

(d) Classification: important orders and their characteristics.

(e) Identification.

*Use of simple keys to orders; pupils should make a collection of common insects, properly mounted and identified to order; pupils should recognize on sight common insects which are agricultural pests in their area (such as *Lygus*, *Stephanoderes*) and carriers of disease (such as *Anopheles*, *Glossina*), and methods of control; nutritional benefits of grasshoppers and termites should be discussed, with respect to protein in human diet.

9. Mammalian anatomy.

   (a) Skeletal system: types of joints and basic skeletal units, such as long bones, vertebrae, scapula, innominate, teeth.

   *Details of skull bones unnecessary; foot and hand bones and names of types of vertebrae can be passed over; pupils should be familiar with names of important long bones.

   (b) Muscles: lever action, nature of origin and insertion.

   *Names of muscles and details of origins and insertions are not necessary.

   (c) Internal organs: location and functions of kidney, liver, spleen.

   *Dissection of frog or small mammal to locate major internal organs.

10. Mammalian physiology, with special reference to humans and cattle.

   (a) Nervous system: nerve cells, nerve fibres, nerves, direction of impulse transmission; central and peripheral nervous systems; sensory and automonic nervous systems.

   *Details of anatomy need not be considered; sensory and autonomic systems should be considered in terms of direction of impulse and function in relation to serving the needs of the body.

(b) The eye and ear: anatomy and function; diseases of the eye; corrective lenses; the ear as an organ of both hearing and balance.

*Beef eye should be examined where available.

(c) The alimentary canal: Morphology; digestion and absorption; enzymes; foods and nutrients; portal vein and storage in liver.

*Good nutrition in livestock and humans should be emphasized; dissections of small mammal to observe alimentary canal, portal vein, and liver; demonstration or experiment showing action of ptyalin, pepsin, pancreatic lipase; special emphasis on kwashiorkor, its cause, symptoms, and prevention; a distinction should be made between foods and nutrients; sources of high and low quality proteins for human nutrition.

(d) Circulation: arteries, veins, capillaries; the heart; circulatory pathways, direction of flow of blood.

*Fresh beef hearts should be examined where possible; circulation of blood through a fish's tail or web of frog's foot should be observed through microscope or microprojector; only major vessels, such as aorta, vena cava, pulmonary vessels need be learned.

(e) Cellular respiration: gas exchange, transport of oxygen and carbon dioxide.

(f) Kidneys: structure of the kidney (medulla, cortex) renal vessels, ureter, bladder.

*Examination of fresh beef kidney where available; details of renal anatomy need not be considered, but function of kidney as a filtration center should be emphasized.

(g) Skin: layers, structure of skin briefly discussed; sweat glands, loss of water, salts, oils.

(h) Endocrines and hormones: regulatory functions and feedback mechanisms of pituitary, thyroids, parathyroids, adrenal medulla.

(i) Sexual reproduction: meiosis and gamete formation; fusion and chromosome doubling; sexual reproduction in man and domestic mammals.

*Dissection of small mammal to show reproductive organs, gential tract of female, location of implantation on uterus.

(j) Development and birth: cleavage, blastula, gastrula, and general pattern of development.

*Details of embryology need not be covered.

11. Mendelian genetics

(a) Chromosomes and genes.

(b) Mutations and alleles: mutations as changes in genes, without going into mutagenic agents; examples of alleles (albinism, golden, etc.).

(c) Mendel's experiments.

(d) Mendelian inheritance: dominance and recessiveness; explanation in terms of genes, chromosomes, gametes; application to domestic animals and plants.

*Pupils should be able to solve simple problems in monohybrid and dihybrid crosses; domestic strains of live-bearing fishes, such as guppies or sword-tails, exhibiting simple Mendelian traits, such as golden or albino, can be maintained in the laboratory to illustrate Mendelian inheritance.

12. Parasites of man and domestic mammals.

(a) External parasites (ticks, bedbugs, fleas, mosquitoes, biting flies).

*Observations of specimen with hand-lens; life cycles, natural history, economic importance as vectors of disease should be stressed.

(b) Internal parasites: roundworms of the alimentary canal (hookworm, pinworm) and methods of control; Bilharzia: vectors, distribution, control measures.

(c) Complex parasitism: onchocerciasis, trypanosomiasis of both man and domestic stock, malaria, yellow fever.

*Assistance of local medical or veterinary personnel should be sought where feasible; life cycles of vectors and causative agents should be studied in some detail; methods of prevention by preventive medicine, chemical sprays, and ecological control of vectors.

A Proposed Biology Syllabus for Higher Schools In Uganda

The proposed higher school biology syllabus emphasizes biological principles and places a substantial portion of the material in an ecological context. It is hoped that this kind of emphasis will help the student who elects biology to see living forms as living dynamic populations and complex communities. Notes to teachers, marked with an asterisk(*), are included in the text to indicate the extent of details and to suggest and recommend activities and exercises.

1. Entomology: morphology and classification of insects; types of metamorphosis; types of mouthparts in relation to feeding; colony organization among social insects; life cycles of tsetse fly, mosquito, grasshopper.
   *Basis of classification to orders without details of wing venation; dissection of grasshopper to show major outlines of internal organization; examination of mouthparts without nomenclature of serial elements.
2. Field studies.
   (a) Plot studies: comparison of several plots with regard to temperatures, plant cover, soil conditions,

exposure, kinds and numbers of animals present.
*Suggested plots: 2 feet X 2 feet, from 6 inches below surface to 6 inches above ground; daily temperature cycles at all levels, daily animal rythms, etc.; ground cover, soil horizons, animal populations; soccer field, untrampled grass, unpaved road, edge of building, etc., make good places for comparisons; each student should work independently, but results should be collated for the whole class.

(b) Line transect studies: vegetation along a line transecting two habitats and associated conditions.
*Habitats studied should be well developed, such as a grassland and forest, or short grass and brush, or dry grass and papyrus; transect line can be a cooperative class study; ground temperatures, exposure to sun, and density and kind of plant cover should be considered.

3. The cell.

(a) General features: cell membrane and permeability; cytoplasm, protoplasm, colloids, imbibition, nucleus and DNA, messenger RNA, enzyme synthesis; diffusion, osmosis, turgor.
*Details to be included are: endoplasmic reticulum; chromatin; properties of colloids, solutions, suspensions; mitochondria.

(b) Mitosis: chromosomes, mitotic figures, phases, chromosome numbers, DNA and replication.

*Stained onion root tip cells or similar materials should be observed with microscope.

(c) Unicellular life: Features of Amoeba, Paramecium, cyanophytes, chlorophytes, bacteria.

*A number of unicellular organisms should be observed, e.g., Paramecium in dilute neutral red or janus green, or Amoeba or Euglena.

4. Lower plants

(a) Bacteria: general morphology of cells; gram stain reactions; nitrogen fixing bacteria; bacteria of decay; bacteria and food poisoning; infectious disease bacteria of man and domestic stock, including epidemiology.

*Simple experiments in culturing colonies on agar plates should be carried out if possible; reference should be made to anthrax and bacillary dysentery and means of control; general symptoms of these diseases, without clinical details.

(b) Green algae: vegetative reproduction; motile gametes and sexual reproduction; cell walls of filamentous forms; chloroplasts.

*Where possible, green algae should be collected from ponds, marshes, or streams, or cultivated from soil by passing water through a column of soil; microscopic examination of both living and stained material.

(c) Fungi: life cycle of phycomycetes as represented by Rhizopus or similar form; nutrition; importance of Penicillium; life cycle of rust fungus, as represented by Hemileia, and control measures; yeasts, budding, and fermentation.

*Rhizopus or similar phycomycete should be cultured in laboratory and studied under microscope; observations of Hemileia material, both macroscopic and microscopic, if available; fruit mash inoculated with yeast should be allowed to ferment for a few days and then be examined for yeast as well as evidence of fermentation.

5. Tissues and organs: colonial organization; growth and maturation of cells; organization of cells into colonies and multicellular organisms; germ layers in animals.

*Observations of such colonial forms as Volvox, filamentous forms, such as Spirogyra, and simple multicellular animals, such as Hydra; observations of prepared slides of germ layers of coelenterates, flatworms to see endoderm, ectoderm, mesoglaea, mesoderm; cell differentiation near growing point of root and shoot tip in vascular plant.

6. Respiratory systems in metazoa: diffusion and water as a vehicle of transport of oxygen and carbon dioxide; lungs, spiracles and tracheae, and gills; chemical bonding of oxygen to respiratory pigments, such as haemoglobin.

   *Implications of iron-deficiency malnutrition for oxygen-carrying capacity of haemoglobin should be pointed out.

7. Vascular plant physiology

   *The teacher should not lose opportunities to use nutritionally desirable food plants as specimen for study and to make frequent reference to their nutritional benefits.

   (a) Soil-water relationships and roots; mineral nutrients.

   *Students should carry out experiments in mineral deficiency solutions, with Hoagland's solution and de-mineralized water as controls (Coleus cuttings or germinating bean seeds); reference to osmosis and turgor.

   (b) Conduction and vascular tissue: xylem and phloem; growing points and differentiation, primary and secondary growth.

   *Microscopic examination of cross-section and longitudinal section of stem and root tips; rise of water through capillary tubing.

*Observations from nature should be made: herbivorous insects, lizards and spiders, ticks and mites on birds and mammals (hosts should be trapped and examined for parasites), ants, vultures; efforts should be made to select a small sample of a habitat and note the total amount of green plant matter, phytophagous insects, and predaceous insects and spiders as illustrations of the food pyramid. (Where does man stand in the food pyramid?)

(c) Commensalism and internal parasitism: Entamoeba coli and E. histolytica, hookworm, Plasmodium, Bilharzia, trypanosomes.

Similarities between commensals and internal parasites (as illustrated by Entamoeba) should be pointed out, along with possible evolutionary relationships; life cycles of Plasmodium falciparum, hookworm, Bilharzia, and Trypanosoma should be learned in detail.

*It should be pointed out that parasitic infections often precipitate acute kwashiorkor.

(d) Ecology and epidemiology of disease: distribution and ecology of sylvan yellow fever; problems of ecological control of tsetse fly by habitat manipulation; problems of control of Anopheles; use of chemical sprays and their limitations; malaria as complex parasitism.

(e) Diseases of livestock and wildlife: nagana, rinderpest, anthrax; causative agents, vectors, distribution, symptoms, control.

9. Sexual reproduction and population expansion.

(a) Sexual reproduction in ferns: life cycle; alternation of generations; dominance of sporophyte.
*Observable gametophytes are freely produced by ferns kept in terraria; sori should be examined with handlens.

(b) Life cycle of gymnosperms: the cone as a branch bearing sporophylls; pollen as spores; seed as an embryonic sporophyte.
*Anatomical details of megagametophytic phase need not be considered, but pollen tube should be recognized as bearing gametic nucleus.

(c) Life cycle of angiosperms: the flower as a cone; comparison of ovary with cone scale; development of fruit; development of endosperm from triploid fusion nucleus.
*Details of types of placentation need not be covered.

(d) Seeds and seed germination: hypocotyl, epicotyl, cotyledons, endosperm; geotropism, phototropism.
*Dissections of seeds of bean and maize; experiments should be carried out by individual students on tropisms of roots and stems, and the effects of

light and darkness on speed of germination and development of chlorophyll.

(e) Sexual reproduction and development in animals: gonads and reproductive tract; gamete fusion and zygote formation; blastula formation and gastrulation; development of germ layers; origin of muscles and internal organs from mesoderm, gut lining from endoderm, skin and nerve tissue from ectoderm.

*Details of embryology need not be covered beyond gastrulation and germ layer formation; dissection of a frog to show gonads and reproductive tracts.

(f) Population expansion and controls: geometrical ratio of increase; limiting factors (food, water, minerals); retarding factors (predation, parasitism, disease, accidents); reference should be made to hippopotamus population and effects on habitat in Queen Elizabeth National Park; sigmoid curve of population expansion.

*Geometrical ratio of increase is well illustrated by the case of a bacterial population in which, beginning with a single cell, fission occurs every twenty minutes; a good mathematical exercise can be presented as follows: assuming that the tufted guinea fowl breeds once per year, has a perfectly balanced sex ratio, lays eight eggs per female, with all pairs breeding, then the increment for the year will be $8 \times \frac{1}{2}$ the population, P. If the attrition rate for the total population, including the young of the year, is 80% per year, at what rate will the population increase or decrease? Ans.: it will remain the same.

10. Genetics and evolution: meiosis and gamete formation; Mendel's experiments; laws of dominance and independent sorting; monohybrid and dihybrid crossing; non-dominance; linkage; mutations and variations; adaptation and natural selection.

*Explanation of transmission of Mendelian traits should always bear reference to meiosis and gametes; genes should be considered as loci on chromosomes and reference should be made to probable role of DNA, messenger RNA, enzyme synthesis centers in cells in expression of inherited traits; frequent reference should be made to examples among agricultural crop plants, such as peas or beans, and domestic livestock, such as cattle or poultry.

11. Vertebrate physiology

(a) Nervous system: central and peripheral; major portions of the brain; sense organs (eye and ear) and their structures; sensory nerves; autonomic nervous system; nerve cells and nerve fibres; direction of impulse.

*Biochemical details of nerve impulse transmission need not be covered, but unidirectional conduction of an impulse along a fibre should be emphasized.

(b) Mammalian circulation: structure and function of heart; pulmonary circulation; arteries, veins, and capillaries; blood plasma; red and white cells; lymph; role of haemoglobin.

*Dissection of fresh beef heart where possible; examination of capillary circulation through web of frog's foot; microscopic examination of fresh blood to show shape of red cells; examination of stained smears to show white cells.

(c) Digestion in man: alimentary canal; enzymes, with special reference to ptyalin, pancreatic lipase (steapsin), and one protein-digesting enzyme; absorption, portal vein, and storage in liver; vitamins and minerals.

*Dissection of a vertebrate to show alimentary canal; demonstration of chemical action of digestive enzymes should be performed; attention should be paid to kwashiorkor, its cause, symptoms, and prevention.

A Proposed Botany Syllabus for Higher Schools in Uganda

The following proposed botany syllabus is predicated upon the idea that an agriculturist is primarily a botanist, and although the subject matter here suggested is designed to introduce the students to a broad and balanced view of the field of plant science, those aspects of botany which are basic to agricultural science and technology are emphasized. It is a conservative syllabus in the sense that the material is largely traditional; this is because the author believes such material best serves the needs of Uganda. Notes to teachers, marked with an asterisk (*), are included in the text to indicate the extent of details and to suggest and recommend activities and exercises.

1. The plant cell

   (a) General features: cell wall, membrane, cytoplasm, nucleus.

   *Microscope observations of green algae, such as *Spirogyra* or similar material, or leaves of *Anacharis*.

   (b) Solutions, colloidal dispersions, suspensions, protoplasm.

   *Physical properties as shown by filtration, light penetration, separation by settling.

   (c) Diffusion, osmosis, turgor, imbibition.

   *Students should observe plasmolysis and carry out experiments using collodion, raw egg membrane, or some other membrane; bean swelling demonstration to show imbibition.

(d) Mitosis: chromosomes, DNA replication, mitotic figures, phases of mitosis.

*Stained onion root tip to show mitotic figures should be observed.

(e) Cytoplasm: vacuoles, endoplasmic reticulum, enzyme and protein synthesis.

2. Vegetative anatomy of vascular plants

(a) Root: growing point, cortical region, root tip region, stele region, elongation and maturation, root hairs.

*Prepared transverse and longitudinal sections of root should be carefully observed.

(b) Stem: primary meristem, primary growth, maturation; xylem and phloem; cambium and secondary growth; cork and bark.

*Prepared cross-sections of herbaceous and woody stems and longitudinal sections of growing points should be observed under a microscope.

(c) Leaf: tissue layers, veins, stomata and guard cells.

*Prepared sections of leaves to show parenchyma; water mounts of lower epidermis to show stomata and guard cells.

(d) External features: leaf form, leaf and branching arrangement, vestiture, growth habits.

*Extensive observations of living materials outdoors, using hand-lens where necessary (as for vestiture).

(e) Floral anatomy: floral parts, position of ovary and perianth, types of placentation.

*Large-flowered forms, such as Hibiscus, Lilium, and Hemerocallis, etc., should be used as much as possible; it is advisable that extensive gardens of cultivated and native plants be maintained around the school grounds for purposes of botanical studies; nutritionally desirable vegetables and fruits might be included, and their value pointed out as they are studied.

3. Physiology of vascular plants

(a) Roots: soil-water relations; minerals, nutrition; soils.

*Roots should be observed from cuttings (e.g., Coleus); experiments with mineral deficiency solutions to observe effects on bean seedlings or Coleus cuttings: nitrogen, potassium, phosphorus deficiencies, compared with Hoagland's solutions and de-mineralized water; field observations of soil cutaway to observe horizons.

(b) Stems: conduction, capillarity.

*Demonstration of water rise in capillary tube, dyes in cut stems.

(c) Leaves: stomata and transpiration.

*Direct observations of transpiration, using cobalt chloride paper, inverted flask over plant in the field, etc.

(d) Photosynthesis: chloroplasts, raw materials and products, factors affecting rate.

*Benedict's test for sugar in leaves of amaryllid or lily kept in dark and light; collection of oxygen in test tube inverted over rapidly photosynthesizing aquatic plants, such as Anacharis.

(e) Translocation and storage.

*Students should conduct extensive experiments, using iodide, Benedict's and xanthoproteic tests, on various plant parts, such as leaves, stems, tubers, bulbs, etc.

(f) Plant growth hormones.

*Simple controlled experiments involving removal of coleoptiles of grass seedlings, such as maize, and phototropic responses.

(g) Tropisms: phototropism, geotropism.

*Simple observations of germinating seedlings and appropriate experiments.

4. Primitive plants

(a) Bacteria: size and form, stain reactions, importance in decay, nitrogen fixation, poisoning, and disease.

*Agar plate cultures from dust, soil, etc.

(b) Cyanophyta and Chlorophyta: unicellular and filamentous forms, differences between the two divisions, reproduction and life cycles, dominance of haplophase.

*Microscopic observations of living and stained specimen.

(c) Molds: form, reproduction, life cycle, importance.

*Culturing and microscopic observations of <u>Rhizopus</u>.

(d) Parasitic basidiomycetes as represented by <u>Hemileia vastatrix</u>.

*Complete life cycle of <u>Hemileia</u> should be learned in detail, and both prepared slides and live material where available should be observed.

5. Bryophytes and ferns

(a) Bryophytes: general morphology, life cycles, habitats, and distribution.

*Either liverworts or mosses may be used; if these do not grow naturally in the area of the school, the teacher should collect specimen when he encounters them on safari and grow them in terraria in the laboratory.

(b) Ferns: general morphology, life cycle, dominance of diplophase, habitats.

*Ferns grown in terraria produce many easily observable prothallia; where climatic conditions are suitable, ferns should be grown around school buildings.

6. Flowering plants

(a) Life cycle of gymnosperms; strobilus as a stem bearing sporophylls; pollination and fertilization; development of seed on sporophylls.

*Compare pine with cycad; pollen should be considered as a spore, and pollen tube as representing gametophytic phase, but details of megagametophytic phase of life cycle are not required.

(b) Economic significance of gymnosperms.

(c) Life cycle of angiosperms: the flower of a strobilus; pollination, triple fusion, zygote and endosperm formation; seed germination and seedling growth.

*Comparison with gymnosperms; condition required for seed germination and seedling growth determined by experiments.

7. Genetics: meiosis and gamete formation; Mendel's experiments, Mendel's laws (dominance, independent sorting); monohybrid and dihybrid crosses; DNA, messenger RNA, and enzyme synthesis as related to gene expression, mutations, variations, and natural selection.

*Students should be able to solve dihybrid crossing problems; the gene should be treated as a chromosome locus, and its relation to DNA pointed out; mutations as changes in nucleic acid structure without reference to details of action of mutagens; frequent reference should be made to examples of genetic traits among familiar plants, such as maize, peas, or garden flowers.

8. Taxonomy

   (a) Characteristics of some prominent families: Leguminosae, Liliaceae-Amaryllidaceae, Convolvulaceae, commelinaceae, Euphorbiaceae.

   (b) Use of taxonomic keys.

   *Lind and Tallantire, 1962: Some Common Flowering Plants of Uganda, Oxford Univ. Press, shs 18/30; students should be able to identify unknowns.

9. Ecology

   (a) Succession in a cleared area: observations of successional changes in herbaceous vegetation, correlation with physical and other conditions, such as temperature and insect life.

   *It would be advisable for higher schools to maintain a field for biological studies, in which the biology teacher could clear sections in sequence for studies in plant succession.

   (b) Major habitats of Uganda: forest, veldt, savannah, papyrus marsh, etc.; habitat structure (stratification, spatial relationships).

   *These should be observed directy to the extent possible; correlations should be made between mean rainfall maps, rainfall dependability maps, and vegetation maps; a comprehensive and extended study should be made of a sample of the native vegetation dominating the area in which the school is located (see Keay, R. W. J.: Vegetation Map of Africa, Oxford Univ. Press, 1959), with respect to dominance and spacing of plant species, community structure, and climatic and physical features (rainfall, temperature records, etc.).

A Proposed Zoology Syllabus for Higher Schools in Uganda

The proposed zoology syllabus which follows emphasizes ecology because of the paramount importance of the problem of field control of parasites and disease vectors widespread throughout the country. It is also hoped that the subject matter of the syllabus will encourage a few students to pursue further work in wildlife biology with a view to service in the Uganda National Parks or Game and Fisheries. It is further hoped that through this syllabus some of the concern and appreciation for wildlife which displays itself so prominently in British culture will be passed on to the Africans. Notes to teachers, marked with an asterisk (*), are included in the text to indicate the extent of details and to suggest and recommend activities and exercises.

1. The cell

   (a) General features: cell membrane and permeability; cytoplasm, protoplasm, colloids, imbibition; nucleus and DNA, messenger RNA, enzyme synthesis; diffusion, osmosis, turgor.

   *Details to be included are: endoplasmic reticulum; chromatin; properties of colloids, solutions, suspensions; mitochondria; plasmolysis should be demonstrated.

   (b) Mitosis: chromosomes, DNA replication, mitotic figures, phases.

   *Stained onion root tip cells or similar materials should be observed with the microscope.

   (c) Protozoans: <u>Amoeba</u>, <u>Paramecium</u>, <u>Euglena</u> as representative free-living protozoans.

   *Any suitable forms may be substituted, according to availability to show general features and variety of unicellular life.

2. Histology: growth and maturation of cells; differentiation into specialized tissue.

   *This section should be practical and consist of intensive laboratory study of various kinds of animal tissues; students should be able to recognize microscopic sections of the following tissues: striated muscle, nerve, bone, cartilage.

3. Mammalian anatomy

(a) Skeletal system: organization of skeleton in terms of skull, vertebrae, long bones, and girdles.

(b) Muscles: striated and smooth.

(c) Thorax: lungs, heart, diaphragm.

(d) Abdominal organs: liver, pancreas, spleen, kidneys; mesenteries; alimentary, urogenital tracts.

(e) Skin, hair, nails, claws; corium and epidermis; hair follicles, sebaceous and sweat glands.

*Dissection of small mammal, such as rat or rabbit (conveniently carried out in connection with mammalian physiology); internal organs need to be dissected only as far as is useful to show general organization (often fresh beef organs can be procured from slaughter houses for this purpose). Sections of skin tissue should be observed; reference should be made to senescence of epidermis.

4. Mammalian physiology.

*Emphasis on human health is urged.

(a) Digestion: classes of foods; the alimentary canal; enzymes; portal circulation and storage in liver.

*Students should know the action of the following: ptyalin, pepsin, invertase, bile salts, pancreatic lipase; where possible, enzyme action should be demonstrated in laboratory; dissection of small mammal to observe alimentary canal, liver, portal vein.

(b) Nutrition: vitamins and minerals; role of carbohydrates, lipids, proteins, vitamins, minerals. *Students should know symptoms, causes, and cures of such deficiency diseases as kwashiorkor, rickets, thiamine deficiency.

(c) Circulatory system: heart; arteries, capillaries, veins; circulatory pathways, direction of flow of blood; pulmonary circulation; blood cells; lymph. *Fresh beef heart should be examined if available; circulation of blood through fish's tail or web of frog's foot whould be observed through microscope or microprojector; only a few major vessels need to be learned; fresh and stained blood smears should be observed for shape of erythrocytes and appearance of leucocytes.

(d) Nervous system: nerve cells, fibres, nerves; direction of impulse in a cell, fibre; structure of eye and ear; sensory nervous system; major portions of the brain with reference to paired cranial nerves; spinal cord; autonomic nervous system; adjustor neurons and reflex arc; conditioned response. *Students should know the difference between nerves and tracts, white matter and grey matter, major divisions of the brain, but details of brain organization are not required; autonomic nervous system should be treated in terms of adaptive responses of body to environmental changes.

(e) Excretion: organization of the kidney.

*Bowman's capsule and other renal details are not essential, but the function of the cortex as a center of blood filtration should be pointed out, with reference to tubules and renal vessels.

(f) Hormones and endocrines: location and function of several endocrine glands and their hormones; pituitary, adrenal medulla, gonads, thyroids, parathyroids; reference should be made to feedback mechanisms.

5. Sexual reproduction and development in animals: gonads and reproductive tract; gamete fusion and zygote formation; blastula formation and gastrulation; development of germ layers; origin of muscles and internal organs from mesoderm; gut lining from endoderm; skin and nerve tissues from ectoderm; implantation in mammals, placenta and embryonic membranes.

*Details of embryology need not be covered beyond gastrulation and germ layer formation; dissection of rat or other small mammal should be carried out to show genital tract and relation of tissue organization to germ layers; prepared and stained chick embryo should be observed for embryonic membranes.

6. Genetics and evolution: meiosis and gamete formation; Mendel's experiments; laws of dominance and independent sorting; monohybrid and dihybrid crosses; non-dominance; linkage; mutations and variations; adaptation and natural selection.

   *Explanation of transmission of Mendelian traits should always bear reference to meiosis and gametes; genes should be considered as loci on chromosomes and reference should be made to probable role of DNA, messenger RNA, enzyme synthesis centers in cells in expression of inherited traits; frequent reference should be made to examples in man and among domestic livestock, such as cattle or poultry.

7. Ecology

   (a) Foods and the food chain: foods as storage of potential energy; classes of foods; food pyramid; herbivorous animals, predatory animals, parasites, scavengers; energy cascade.

   *Observations from nature should be made; herbivorous insects, lizards and spiders, ticks and mites on birds and small mammals (hosts should be trapped and examined for parasites), ants, vultures; efforts should be made to select a small sample of a habitat and note the total amounts, respectively, of green plant matter, phytophagous insects, and predaceous insects and spiders as illustrations of the food pyramid.

(b) Commensalism and internal parasitism: Entamoeba coli and E. histolytica, hookworm, Plasmodium, Bilharzia, Trypanosoma.

*Similarities between commensals and internal parasites should be pointed out, along with possible evolutionary relationships; life cycles of Plasmodium falciparum, hookworm, Bilharzia, Trypanosoma and vectors involved should be learned in detail; it should be pointed out that parasite infections often precipitate acute kwashiorkor.

(c) Ecology and epidemiology of desease: distribution and ecology of tsetse fly by habitat manipulation; problems of control of Anopheles; use of chemical sprays and their limitations; malaria as complex parasitism.

(d) Diseases of livestock and wildlife: nagana, rinderpest, anthrax; causative agents, vectors, distribution, control, symptoms.

(e) Population studies: population expansion and controls; geometrical ratio of increase; limiting factors (food, water, minerals); retarding factors (predation, parasitism, disease, accidents); reference should be made to hippopotamus populations in Queen Elizabeth

National Park and their effects on habitats; sigmoid curve of population expansion. *Geometrical ratio of increase is well illustrated by the case of a bacterial population, in which, beginning with a single cell, fission occurs every twenty minutes; a good mathematical exercise can be presented as follows: assuming that the tufted guinea fowl breeds once per year, has a perfectly balanced sex ratio, lays eight eggs per female, with all pairs breeding, then the increment for the year will be 8 x $\frac{1}{2}$ the population, P; if the attrition rate for the total population, including the young of the year, is 80% per year, at what rate will the population increase or decrease? (Ans.: it will remain constant); population curves can be obtained experimentally with small colonies of mealworms.

(f) Autecology: each student should select a species of small easily observable animal, such as a gecko, blue agama, cockroach, or chameleon, and make extensive field studies and laboratory observations of its daily rhythms, diet, spacial adaptations, breeding habits and reproduction, defense against enimies, habitat, etc.

(g) Wildlife biology: important wildlife species of Uganda (elephant, hoppopotamus, white rhinoceros, waterbuck, buffalo, eland) and their distribution, habitat preferences, diet, defensive habits, identification, conservation problems.

"Visits should be made to one of the national parks if possible (contact Uganda National Parks for details of special accomodations for school groups).

8. Economic entomology

(a) General morphology and classification of insects to orders; mouthparts in relation to feeding.

(b) Anatomy and physiology; respiratory system, including internal organs and alimentary canal.

(c) Identification of those forms of economic or public health significance (e.g., Aedes, Anopheles, Glossina, Antestia, Stephanoderes, Lygus, Earias) in the area in which the school is located. Nutritional value of food species (grasshopper and termite) should be pointed out.

A Comparison

A difference between the Cambridge syllabi and the proposed syllabi is that emphasis in the Cambridge syllabi is clearly on structure and classical physiology of organisms, whereas the proposed syllabi, while recognizing the importance of those areas, has tried to add an emphasis on ecology. Both the Cambridge and the author's proposals are centered around holobiology, but the proposed syllabi add a community and population dimension to the purely organismal level of the Cambridge syllabi. Finally, of course, the proposed syllabi attempt to adapt biology instruction to Ugandan needs by introducing those principles of biology which are especially relevant to the native setting, using native cases as illustrative material.

The Cambridge School Certificate Syllabus makes no mention of recommended class periods to be spent on each topic, but the Higher School Certificate syllabi are quite precise on the point. The present author is unwilling to make such recommendations at present, because they would have to be based on the experience of classroom teachers and arrived at by consensus of those teachers after a trial period.

A comparison of the proposed syllabi with the present Cambridge syllabi in terms of topic headings has the serious limitation that topics in the two syllabi are not necessarily precisely alike in content. Furthermore, a given subject may be treated as a unified topic in one syllabus and be distributed among several topics in another. Nevertheless, in the hope that a sense of the difference in emphasis can be gained by a comparison list of topics an attempt has been made below to indicate the degree of overlapping between the proposed and current syllabi by juxtaposing essentially similar topics in both courses of study and setting apart non-parallel topics.

Proposed Secondary School Biology Syllabus	Cambridge School Certificate Biology Syllabus
The cell	
Survey of the plant and animal kingdoms	
Soil study	
Mendelian genetics	
Parasites of man and domestic animals	
Ecology	Ecology
Lower plants	Microscopic plants
Vascular plant morphology and taxonomy	Flowering plants
Vascular plant physiology	Plant physiology
Insect morphology and taxonomy	Insects: general features and life history
Mammalian anatomy	Structure and physiology of a mammal
Mammalian physiology	
	External features of a vertebrate
	Amoeba

Proposed Higher School Biology Syllabus	Cambridge Higher School Certificate Biology Syllabus
Entomology	
The cell	
Lower plants	

Tissues and organs	
Respiratory systems in metazoa	
Foods and food chain	
Sexual reproduction and population expansion	
Field studies	Natural history
Vascular plant physiology	The flowering plant
Genetics and evolution	Reproduction, heredity, and evolution
Vertebrate physiology	The mammal
	The variety of organisms
	Elements of structure and physiology
	The soil
	Relations of organisms to disease and decay

Proposed Higher School Zoology Syllabus	Cambridge Higher School Certificate Zoology Syllabus
The cell	
Histology	
Economic entomology	
Mammalian anatomy	The mammal
Mammalian physiology	
Sexual reproduction and development in animals	Embryology, genetics, and evolution
Genetics and evolution	
Ecology	Natural history
	Other animals
	Relations of animals to man

Proposed Higher School Botany Syllabus	Cambridge Higher School Certificate Botany Syllabus
The plant cell	
Primitive plants	
Genetics	
Vegetative anatomy of vascular plants	Morphology of flowering plants
Physiology of vascular plants	Physiology
Bryophytes and ferns	Flowerless plants and *Pinus*
Flowering plants	Reproduction of flowering plants
Taxonomy	Systematic botany
Ecology	Natural history of flowering plants
	Variation

APPENDICES

APPENDIX A

CURRENT CAMBRIDGE BIOLOGY SYLLABUS FOR SENIOR SECONDARY SCHOOLS[1]

The papers in biology on the Cambridge School Certificate Examination and General Certificate of Education (Ordinary Level) Examination are based on the following syllabus. Paragraphs in single space are notes indicating scope and detail and suggesting activities.

1. The general elementary structure and physiology of a mammal.

   It is suggested that a small mammal, e.g. rabbit, rat, or guinea-pig be used for most of the work, but it is important that there should be frequent reference to man.

   (a) The main structural features of a mammal including the general arrangement of the internal organs. External features in relation to habits and environment.

   Candidates should be familiar with the appearance and position of the internal organs referred to in the syllabus through actual dissections shown them by the teacher. They will not be expected to reproduce from memory drawings of complete dissections they have seen.

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[1]Cambridge University Local Examinations Syndicate, Syllabuses, Science Subjects: General Certificate of Education (Ordinary Level) and School Certificate (1961), pp. 47-52. By permission, Cambridge University Local Examinations Syndicate.

(b) The general plan of the skeleton and its functions. Different types of joints as illustrated by shoulder, hip and the elbow and the way muscles act on bones to cause movement. The structure and function of vertebrae: atlas, axis, cervical, thoracic and lumbar vertebrae.

Details of the structure of the skull are not required, nor are the names of the individual bones of the pelvis. A vertebra should be regarded as being composed of a body (centrum) carrying arches, neural spine and transverse processes with facets for articulation. The names of the articulatory processes will not be required.

(c) The structure of a tooth and its insertion in the jawbone. Incisors, canines, premolars and molars. The relation of dentition to diet as illustrated by man, a herbivore and a carnivore.

(d) The alimentary canal. Food substances and diet. Digestion, including the functions of the liver and pancreas. Absorption, transport and utilization of digested food. The function of the liver in the general body metabolism.

Tests for reducing sugar, starch, protein (one test only), and fats should be carried out by the candidate. The importance of vitamins and enzymes should be stressed. Names of specific enzymes will only be required in the case of ptyalin, rennin and pepsin, but the candidate should understand that there are specific enzymes in the small intestine acting on proteins, carbohydrates and fats. The action of ptyalin, rennin, and pepsin should be studied experimentally.

(e) The main features of the circulatory system. The structure of the heart. Structure and functions of the blood. Capillary circulation.

Names will be required only of main blood vessels of the liver and kidney and those entering and leaving the heart. Blood should be examined microscopically. To demonstrate capillary circulation a tadpole's gill or tail can be used or a frog can be conveniently anaesthetized (for at least an hour) by immersion for 20 min. in a 1% solution of urethane; the capillaries can be seen in the web between the toes.

(f) Respiration. The respiratory organs and the mechanism of breathing. Tissue respiration. The role of oxygen in the operation of energy for the activities of the living body.

(g) Excretion by kidneys, sweat glands, lungs. Elementary treatment of the structure of the kidney and of filtration and reabsorption.

The kidney should be treated as comprising cortex and medulla and consisting of a branched system of tubules, well supplied with blood-vessels, leading to the ureter. Details of the courses of the tubules and their blood-vessels will not be required.

(h) Structure and functions of the skin.

(i) Regulation of body temperature and the importance of the maintenance of a constant body temperature.

A vertical section of the skin should be examined with the aid of a microscope or a microprojector.

(j) A simplified account of the brain and spinal cord. Reflex action and how it differs from voluntary action. The principal sense organs, their position and function. The structure of the eye and ear simply treated. The use of spectacles for the correction of long sight and short sight.

Only the external structure of the brain is required, but reference should be made to the distribution of white and grey matter. The ear should be treated as consisting of a cochlea sensitive to vibrations and semicircular canals sensitive to position; Questions involving detailed structure of the membranous labyrinth will not be set.

(k) The co-ordination of the body functions by means of hormones, e.g. thyroxin, adrenalin and insulin. Names of other hormones will not be expected.

(l) The reproductive organs and a general outline of the development, nutrition, respiration, and birth of the embryo.

Details of the cell divisions and the anatomy of the embryo are not required.

2. (a) External features, habits, movements, and life history of a fish (including gills), a frog, a bird, and a small mammal.

Candidates will be expected to study living examples, and to make records of their own observations. They should consider how the animals are adapted to their environment and the type of life. No more detail is expected than can be seen with the aid of a hand lens.

(b) Development of frog from fertilization to complete metamorphosis.

Candidates will not be expected to know any details of cleavage, but they will be expected to have examined the different stages with the aid of a hand lens.

3. Insects. The general characteristics of insects as illustrated by a study of the external features of a cockroach.

Knowledge of the individual joints of the mouth-parts or other appendages will not be expected.

Outlines of the life history, mode of life, and the economic importance of: cockroach, butterfly (or moth), mosquito, house-fly, green-fly, clothes moth, honey-bee.

Candidates should make their own observations of the insects in their natural surroundings, and these should be supplemented by records made from living specimen in the laboratory.

4. The microscopic appearance and movements of Amoeba (or Paramecium, excluding details of conjugation) and Hydra, including an elementary knowledge of their methods of nutrition and reproduction.

The appearance and movements of Amoeba should be demonstrated under the microscope, using a 2/3 in. objective, or with a microprojector. High powers of resolution are not required.

5. Flowering Plants.

(a) Outlines of the external morphology of a herbaceous plant.

(b) Characteristic features of at least three of the following trees in summer and in winter: ash, beech, birch, elm, horse chestnut, larch, oak, plane (or sycamore), Scots pine, willow.

The study of a tree should include a very elementary treatment of secondary thickening, including formation and functions of bark, (paying attention only to features that can be seen with the aid of a hand lens) and the part played by the absciss layer during leaf-fall.

(c) Stem, root and leaf to be treated with reference to their functions and to experiments in plant physiology. (See section 6 below.)

The internal structure of stem, leaf and root.

Candidates will be expected to have examined by microscope or microprojector transverse sections of the stem, leaf and root of a herbaceous dicotyledon, e.g. sunflower, but they will not be required to reproduce from memory drawings showing details of cell structures.

(d) The parts of a flower and their functions. The detailed mechanism of pollination in not more than three insect-pollinated flowers and one wind-pollinated flower. Fertilization and the development of fruits.

Fertilization should be treated without reference to microscopic detail other than the growth of the pollen tube and fusion of nuclei. This should be studied, where possible, in the same flower as a sequence of pollination.

(e) Fruit and seed dispersal.

Candidates should be familiar with two examples each of wind-dispersal and animal-dispersal (an internal and an external method), and one example of self-dispersal.

(f) The structure and germination of seeds.

Candidates will be expected to have seen one example of epigeal and one of hypogeal germination.

(g) Herbaceous perennials illustrating different types of storage organs and vegetative reproduction.

Examples of vegetative reproduction should be chosen, as far as possible, for their ecological importance. Vegetative reproduction and reproduction by seed should be compared.

6. Plant Physiology.

(a) The processes of diffusion and osmosis. The absorption of water and mineral salts. The importance of turgor. Water or sand cultures.

These processes should be shown with an artificial cell and with living material.

(b) The rise of water up the xylem vessels.

The path should be demonstrated by the use of dyes. Questions will not be set on causative forces.

(c) The process of transpiration.

Experimental work should include the loss of weight of a potted plant or of a leafy shoot in a test-tube, the use of cobalt chloride paper, and the effect of external conditions on the rate of water loss. When a potometer is used, its limitations should be stressed.

(d) Photosynthesis: the nature of the process itself, and the use of the manufactured food. The great importance of photosynthesis to life in general.

The candidates should be able to show by experiments the necessity for light, carbon dioxide and chlorophyll; the formation of starch and the output of oxygen.

(e) Respiration: the nature of the process and its significance in other vital activities. The carbon cycle and energy exchange. Food chains.

Experiments should be carried out on gaseous exchanges, and on heat production. Links should be made here with the animal kingdom, showing the

interdependence of animals and plants.
Food chains; at least one should be chosen from the local environment.

(f) Growth and its relations to external stimuli.

This should include the regions of growth in root and shoot, geotropic response of primary roots and shoots, phototropism of shoots and hydrotropism of roots.

(g) Conditions for seed germination, and further conditions for subsequent healthy growth of seedlings into mature plants.

(h) Soils; their constituents, and their characteristics.

Candidates will be expected to have carried out simple experiments on the physical properties of soil. They should know how to determine the amount of air, water and humus (by ignition), and how to compare capillarity and porosity of different samples of soil.

(i) The nitrogen cycle, including the living organisms, which play a part in it.

Names of individual bacteria are not required.

Manuring and the rotation of crops.

This should be simply treated.

7. Microscopic Plants. Structure, nutrition, and life history of <u>Spirogyra</u> and <u>Mucor</u> (or other mould fungus).

8. Ecology. The relation of plants and animals to their environment based on studies of

(a) aquatic habitats (seashore between the tide marks or ponds or streams or marshes);

(b) terrestrial habitats (grassland or lawns or gardens or hedgerows or woods).

A question on this section will always be set in the paper Biology I, but there will be a sufficient number of questions in the paper to allow candidates who have not had opportunities of making observations in the countryside, a good choice without answering the question in ecology.

9. Some of the questions will assume a knowledge of the subject matter of the following paragraphs, but direct questions on the more general principles will be avoided:

(a) A brief treatment of saprophytic and parasitic modes of nutrition. Disease bacteria and the chief methods of combating them.

(b) Cell structure of plants and animals demonstrated by means of a microscope or microprojector. Cell wall, nucleus, and cytoplasm for one simple cell. Elementary notion of cell differentiation in association with function illustrated by reference to some of the different types of cell present in different organs or tissues.

APPENDIX B

CURRENT CAMBRIDGE BIOLOGY SYLLABUS FOR HIGHER SCHOOLS[1]

The papers in biology on the Cambridge Higher School Certificate Examination and General Certificate of Education (Advanced Level) Examination are based on the following syllabus. Paragraphs in single space are notes indicating scope and detail and suggesting activities.

1. The mammal. (90 periods.) The external features and elements of the structure and physiology of a mammal exemplified where necessary by the study and dissection of the rabbit (or rat or mouse) and with special reference to man. As an introduction to the dissection of the rabbit (or rat or mouse) the frog should be dissected to show the general anatomy of a tetrapod vertebrate.

   (a) The skeleton (without details of the skull except the teeth); the general relation of muscles to the skeleton in producing movement. Names of muscles and details of the chemistry of muscle action are not required.

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[1] Cambridge University Local Examinations Syndicate, Syllabuses, Science Subjects: General Certificate of Education (Advanced Level and Special Papers) and Higher School Certificate (1961), pp. 43-49. By permission, Cambridge University Local Examinations Syndicate.

(b) The skin; hair, nails or claws. Sweat and sebaceous glands. Temperature control.

(c) The digestive system; the constituents of a balanced diet; enzyme action.

(d) The vascular system and the circulation, composition and functions of blood and lymph.

(e) The respiratory organs. The mechanism of breathing. Gaseous interchange in the lungs and tissues. Internal (tissue) respiration, without biochemical details.

(f) The excretory system. The kidneys, with a simplified account of the action of urinary tubules.

(g) Hormones. The function of the endocrine systems emplified by the production and effects of adrenalin. Brief reference should be made to the existence of other endocrine glands. Details of histology and biochemistry will not be required.

(h) The nervous system, limited to the main regions of the brain, the spinal cord, the autonomic nervous system, sense organs, reflex actions and a simple study of behaviour, play and learning.

(i) The reproductive system and an outline of the development and care of the young.

(j) The defence of the body against injury and infection. See note to section 1 of the Zoology syllabus.

2. The flowering plant. (110 periods.)

(a) The elements of the structure of a flowering plant such as sunflower or wallflower with sufficient microscopical detail to make clear the development and functions of the root system, the stem and the leaf.

(b) The elements of the physiology of the green plant: viz. photosynthesis; respiration; uptake of minerals; uptake, conduction, and loss of water; growth and tropistic response. The water-relations of the cell and absorption of solutes: turgor-pressure, suction-tension and plasmolysis.

(c) Reproduction by seed: the structure of two simple flowers, e.g. buttercup and bean; pollination, the differences between wind and insect-pollinated flowers; fertilization; formation of fruits and seeds and their dispersal. No details of development of ovary, embryo-sac, and stamens are required. Germination (of sunflower and wheat) with changes taking place in stored food.

(d) Perennation and vegetative reproduction, and their importance in nature and cultivation. Food storage in perennating organs; specialized storage organs--rhizome, tuber, corm, bulb, modified root. Seasonal changes in herbs and woody plants, including seasonal changes in secondary growth, the microscopic features of this secondary growth being treated in simple outline only. The work on perennation and vegetative reproduction should be closely linked with field and/or garden studies.

Flowering plants play a preponderant role in the vegetation of the world and largely determine the environment of most animals, including man. They are not only the source of important products such as timber, cotton, rubber, but by virtue of their photosynthetic powers are the ultimate source of most of the food-supply for the human race and many other animals. Practically the whole of our food-crops come from flowering plants. Students should be made to realize that the practice of agriculture, horticulture and forestry can be related to our knowledge of the physiology and biology of the flowering plants.

A range of interesting and important observations can be made on the biology of wild and crop-plants without need either of microscopic technique or elaborate experiments. Furthermore these plants can most conveniently be employed in schools in physiological experiments, which form such a good introduction to the experimental study of living organisms. Lastly, some of the most interesting fields of biology which concern the interrelations of plants and animals demand a general knowledge of flowering plants; e.g. pollination and dispersal mechanisms, food-relationships in general, and of plant disease. The following points should, as far as possible, be demonstrated by experiments;

Photosynthesis; formation of carbohydrates and liberation of oxygen; essential factors. Removal of carbohydrates from an attached darkened leaf.
Water up-take and transpiration; effect of external factors on rate of water-loss (by weighing methods); use of cobalt chloride paper; use of potometer.
Germination; conditions required.
Geotropism; in root and stem. Phototropism in leaf. Perception, conduction and response, and outline of the mechanism.
Respiration; absorption of oxygen, and production of carbon-dioxide and heat. Anaerobic respiration.
Turgor; plasmolysis, recovery, wilting.

3. The variety of organisms. (95 periods.) A general study of the following organisms but with special reference to the points indicated after each, with dissection where appropriate, and observation of living specimen where possible.

(a) Euglena: nutrition, movement, comparison of animals with plants.

(b) Amoeba: protoplasm, nutrition, irritability, movement, action of contractile vacuole, life-history.

(c) Spirogyra: the green plant cell contrasted with the animal cell; reproduction including conjugation.

(d) Mucor: structure, nutrition, reproduction (asexual and sexual). Puccinia: parasitic habit. Yeast: respiration (aerobic and anaerobic); fermentation of sugar; economic importance.

(e) Fucus: Differentiation, adaptation, sexual reproduction.

(f) A liverwort, e.g. Pellia (or a moss, e.g. Funaria): microscopic structure, life-history, and adaptations to conditions of life of both generations.

(g) Hydra: differentiation and specialization of cells, reproduction (asexual and sexual). Behaviour.

(h) Ascaris (or Oxyuris or Ankylostoma): life-cycle and parasitic habit.

(i) Earthworm: specialization of tissues into organs; the body-cavity, vascular system, alimentary canal, nutrition, central nervous system, behaviour, reproduction and life-history, economic importance.

(j) Insects: omitting internal structure; feeding without details of individual mouthparts; ecdysis, types of metamorphosis. Cockroach: external features, respiration, life-history. Butterfly: life-history. Honeybee: social life and economic importance. Mosquito: life-history and economic importance. An Aphid: e.g. bean aphis: annual life-cycle; parthenogenesis and economic importance. Housefly (or blowfly): life-history and economic importance.

(k) A fish: external features and gills only.

(l) Frog: external features, respiration, transition from aquatic to terrestrial life, life-history omitting embryological details.

The object of this section is to introduce the student to other important types of living organizations in the world and their relationships to each other. The various aspects of the interrelations of these organisms are considered in subsequent sections of the syllabus.

The study of Amoeba gives information about protoplasmic structure and animal at a minimum or permanent structural organization; it ought not to be considered as an example of a primitive animal. Euglena is included as an example of a type of organization from which both plants and animals can be derived. Bacteria should be dealt with very simply as suggested in section 6.

4. Elements of structure and physiology. (67 periods.)

Sufficient knowledge of the following to permit appreciation of physiological processes: acids, bases and salts; carbohydrates, fats and proteins; chemical change, catalysis; enzymes; solutions, colloidal systems, diffusion, permeability of membranes, osmotic pressure.

The cell, nucleus and cytoplasm, mitosis, cell-division. Cell differentiation and tissue formation, including vascular tissues of the flowering plant and the histology of blood, cartilage, pavement epithelium, ciliated epithelium, and striated muscle.

Characteristics of living organisms; similarities and differences between plants and animals, including the energy relations. Holophytic, holozoic, saprophytic and parasitic nutrition. The nutrition of micro-organisms compared with that of higher plants and animals.

This section is meant to give opportunity for a generalized treatment of fundamental features of physiology, structure and behaviour of living organisms, commencing with the features common to most organisms and indicating the differences emerging with differentiation of plant and animal types, and with the various modes of nutrition. It should be indicated in what way all the primary distinguishing features of plant and animal life relate to the basic differences in their nutrition. Simple experiments, e.g. on osmosis, should be included if these have not been covered in some other subject.

5. The soil. (20 periods.) The soil in relation to plant and animal life; origin and structure; humus, mineral and water content; natural and artificial manures; activities of soil organisms; carbon and nitrogen cycles; rotation of crops.

In view of the teeming life of the soil, the role it plays as the determinant of plant and animal communities, and the importance of soil fertility to food-production, it is desirable to call separate attention to it in biology teaching. It is suggested that simple experiments upon soil should be included in the practical work.

6. Relations of organisms to disease and decay. (26 periods.) A brief mention of bacteria in relation to the circulation of substances in nature, and to disease and industrial processes. Brief reference to other pathogenic agents such as viruses, Protozoa. Parasitism. *Puccinia* as a parasitic fungus. *Ascaris* (or *Oxyuris*) as an example of an animal parasite. Brief mention should be made of parasites of economic importance, e.g. *Phytophthora infestas* (potato blight), "eel-worm" in agriculture, hookworm. Animal vectors and their control. Housefly (or blowfly). Mosquito. Louse. Control of disease in relation to elementary hygiene and public health.

The section includes topics suitable to very advanced and extensive treatment, but the small allocation of periods (26) which is proposed will indicate the nature of the treatment expected. In many instances this will be more a presentation of the biological problems raised by certain issues of great importance to the life of the world, than an exposition of present scientific knowledge. In some instances, of course, simplified explanations can and should be given.

7. Reproduction, heredity, and evolution. (22 periods.) Variation. Outlines of Mendelian inheritance for not more than two pairs of characters.

An outline of the behaviour of the nucleus in the maturation of the germ-cells and in fertilization. The place of meiosis in the life-cycle. Students should realize the importance of the pairing and subsequent separation of homologous chromosomes, but a detailed study of meiosis is not required. Outline of the concepts of evolution and natural selection, and the nature of the evidence for them without consideration of specific theories of the mechanisms of evolution.

Attention should be directed to the fact of evolution; controversies over the details of how it has come about should only be touched upon lightly. The arguments which it is desirable to present to the student are such as are found in the earlier chapters of the Origin of Species.

8. Natural history: organisms in relation to habitat. (20 periods plus spare time.) The natural history in some detail of the plants and animals within two well-defined habitats chosen from the following: the sea-shore; woodlands; moorland; heath or chalk down; freshwater ponds and streams; hedgerow and waste ground; grassland; swampy ground (marsh, fen, or bog). Attention should be given, wherever possible, to the observation and record of the interrelations between the plants and animals, and the influence of soil, climate, human

and other biotic factors. Candidates in the United Kingdom who are especially interested in natural history may offer Field Work as an additional item for examination.

Great importance is attached to the encouragement of individual field work. It should be stressed that this subject does not necessarily call for teaching of ecological concepts and nomenclature, but rather for a direct stimulus to students, individually or in classes, to make their own observations in the field upon the intimate biology of the species which they encounter, and upon the relations between such species themselves, and between them and the environment. It is suggested that the teacher should help the student by displaying to him lines along which such studies can be made, that the student should be encouraged to pursue such work on his own according to his personal interests, and that field study should not be systematized into a regular course of teaching.

There is in this field the most stimulating opportunity to develop an approach of intrinsically "biological" character, when the study is not one of merely plant and animal life, but of the integrated activity of the organisms in the natural community.

APPENDIX C

CURRENT CAMBRIDGE BOTANY SYLLABUS FOR HIGHER SCHOOLS[1]

The papers on botany on the Cambridge Higher School Certificate Examination and General Certificate of Education (Advanced Level) Examination are based on the following syllabus. Paragraphs in single space are notes indicating scope and detail and suggesting activities.

1. Morphology of flowering plants. (84 periods.) The external morphology of typical British dicotyledons and monocotyledonous herbs. The main anatomical features of the roots, stems, and leaves of the herbaceous dicotyledon, and a monocotyledon such as maize. Primary and secondary growth. Differentiation and formation of tissues. Arborescent plants; the external morphology of four common trees and the main anatomical features of one: bark; leaf-fall. Perennation; storage organs; vegetative reproduction. Protoplasm (cytoplasm and nucleus); the plant cell and its contents. Mitosis and cell-division.

   In the past the study of morphology has often included only the work that can be carried out in the laboratory, e.g. the examination of the internal

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[1]Cambridge University Local Examinations Syndicate, Syllabuses, Science Subjects: General Certificate of Education (Advanced and Special Papers) and Higher School Certificate (1961), pp. 27-30. By permission, Cambridge University Local Examinations Syndicate.

structures of stems and roots of dicotyledons and monocotyledons. Too little attention has been paid to the external form of plants, including details of bud structure and leaf form. Plants, including trees, are to be found growing almost everywhere, and no opportunity should be lost in making studies of them in the open. Trees in recreation grounds, churchyards, and parks often provide the opportunity for this study in towns, whilst smaller plants and weeds can be studied in gardens or even backyards. When studying the morphology of flowering plants products such as timber, cork, rubber, cotton, sisal should be borne in mind, not only in their final forms, but also the fact that they are products of living cells.

2. Physiology. (114 periods.) The water relations of the cell and the absorption of solutes. Maintenance of soil fertility; manuring and crop rotation, the nitrogen cycle. Culture solutions. Photosynthesis. Translocation and storage of food. Transpiration and water movement. Respiration, aerobic and anaerobic. Growth. Response to stimuli; geotropism, phototropism and hydrotropism. An elementary study of enzymes and their role in plant metabolism. Sufficient knowledge of the following to permit appreciation of the physiological processes; salts, solutions, colloids, diffusion, permeability of membranes, osmotic pressure, the elementary chemistry of carbohydrates, fats and proteins including simple qualitative tests for common reserve foods, rate of chemical change, catalysis.

The process of photosynthesis and respiration should be treated in an elementary fashion and as physiological processes; details of complex biochemical reactions are not required.

The largest amount of time has been allotted to the study of the physiology of the flowering plant, not only because a great deal of what is known of the physiological processes of plants is based on the flowering plant, but also because most of our crop plants are flowering plants The student should be made to realize that the practice of agriculture, horticulture and forestry can be related to our knowledge of this physiology. It is desirable that the student should make observations and simple experiments in the open as well as in the laboratory. If it is impracticable to conduct experiments in any particular natural habitat it might be found possible, for instance, to carry out in the school garden an investigation of plant growth in relation to the composition of the soil.

3. Reproduction of flowering plants. (57 periods.) The morphology of the common categories of inflorescences and flowers considered in relation to pollination; anthers and ovules including their microscopic structure. Fertilization and its results (omitting details of embryo development). Fruit and seed formation and dispersal. Germination.

Any study of reproduction in flowering plants that does not treat the process as one phase in the life cycle of the plant can have little value. It is common, however, in answers to examination questions to find that many candidates who are able to describe adequately, and in detail, the formation of gametes are ignorant of floral morphology and pollination mechanisms. The student should be encouraged to make his own observations on flowers, the ripening of fruits and dispersal of seeds in the countryside or in his own garden. Simple observations can be carried out to test the efficiency of various methods of dispersal.

4. Flowerless plants and Pinus. (73 periods.) The structure, nutrition and life-history of *Chlamydomonas*, *Spirogyra*, *Fucus*, bacteria, yeast, *Mucor*, *Puccinia*. The life-history

of a liverwort (e.g. Pellia), a moss (e.g. Funaria), a fern, and Sellaginella (candidates should study specimen of these four types, but knowledge of their detailed anatomy is not required). The external morphology, life-history and main anatomical features of Pinus.

The study of the plants listed in this section is intended to introduce the student to the wide variety of organisms in the plant kingdom and their ecological relationships, and also to provide examples for the study of the theory of evolution. The inclusion of fungi provides opportunities for discussing plant disease and methods of control, fermentation and its economic importance, and the part played by fungi in bringing about decay.

5. Natural history of flowering plants. (28 periods not including field work.) Annuals, biennials and perennials. Water plants, xerophytes, climbing plants, parasitic plants and insectivorous plants. Ecology; the soil in relation to plant life; its origin and structure; humus, mineral and water content; observations and records made throughout the year of at least two types of vegetation (e.g. seashore, woodland, grassland, heath, moor or fen, salt-marsh, aquatic, hedgerow, waste ground) with reference to soil, climatic, biotic and human influence.

If efforts are made throughout the syllabus to encourage observations in the open much of the difficulty so frequently encountered in this section should disappear. The students will already have acquired a good knowledge of plant form in relation to the mode of life. It now remains to see how plants fit into their natural environment. This can be done by periodic observations of the class on selected habitats supplemented by the students' individual observations. Candidates in the United Kingdom who are specially interested in natural history may offer Field Work as an additional item for examination.

6. Systematic botany. (50 periods.) Principles underlying the classification of plants; the meaning of the terms species, variety, genus, family. Study of the characters used in classification as illustrated by the commoner members of the Ranunculaceae and Rosaceae; a less detailed knowledge of the Cruciferae, Leguminosae, Scrophulariaceae, Labiatae, Compositae, Liliaceae and floral structure of one species of grass. Candidates should be able to identify British plants by means of a Flora.

The attention of students should be drawn to the uniformity of plan that prevails among flowers, and to the variations in the relations of parts characteristic of the different families. The characters used in classification can usually be exemplified by study of differences between pairs of related species. It is important that students should be able to identify flowering plants with the aid of a Flora.

7. Variation. (18 periods.) Phenotypic and genotypic variation. Outlines of Mendelian inheritance for not more than two pairs of characters. Elementary knowledge of meiosis, including some knowledge of linkage and crossing over. (Calculations involving crossing over will not be set.) Outlines of the concept of evolution; evidence for evolution in the past and at present.

It is difficult to draw a satisfactory elementary syllabus for genetics, although a knowledge of its elements is necessary in any elementary biological training. An arbitrary line has therefore been drawn to exclude complex modern views on the structure of chromosomes.

It is intended here that attention should be particularly directed to the fact of evolution and that controversies over the details of the method by which it takes place should only be touched upon lightly. Even if the argument of the modern genetical theory of evolution can be understood by the elementary student, his biological background is not strong enough for him to make use of it. In introducing the concept of evolution an unnatural prominence has often been given to evidence derived from the study of anatomy and embryology. As reference to the _Origin of Species_ will show, evidence of this kind provides no more than collateral support for the theory. The arguments which it is desirable to present to the student are such as are found in the earlier chapters of the _Origin of Species_ itself.

APPENDIX D

CURRENT CAMBRIDGE ZOOLOGY SYLLABUS FOR HIGHER SCHOOLS[1]

The papers in zoology on the Cambridge Higher School Certificate Examination and General Certificate of Education (Advanced Level) Examination are based on the following syllabus. Paragraphs in single space are notes indicating scope and detail and suggesting activities.

1. The mammal. (90-130 periods.) The external features and elements of the sturcture and physiology of a mammal exemplified where necessary by the study of the rabbit (or rat or mouse), and with special reference to man:
   - (a) The skeleton (without details of the skull) and the general relation of muscles to the skeleton in producing movement. Names of muscles will not be required.
   - (b) The skin: hair, nails, or claws, sweat and sebaceous glands. Temperature control.
   - (c) The elementary physiology of muscular exercise. Details of the chemistry of muscle action should not go beyond the glycogen-lactic acid system

[1] Cambridge University Local Examinations Syndicate, Syllabuses, Science Subjects: General Certificate of Education (Advanced and Special Papers) and Higher School Certificate (1961), pp. 32-41. By permission, Cambridge University Local Examinations Syndicate.

(d) The main features of the omnivorous, carnivorous, and herbivorous dentitions. The digestive system, the constituents of a balanced diet, enzyme action.

(e) The vascular system and the circulation, composition and functions of blood and lymph.

(f) The respiratory organs. The mechanism of breathing. Gaseous interchange in the lungs and tissues. Internal (tissue) respiration, without biochemical details.

(g) The excretory system. The kidneys, with a simple account of the action of urinary tubules.

(h) The defences of the body against injury and infection.

(i) Hormones, secretin. The function of the endocrine system, as exemplified by the thyroid, adrenals, pituitary, islets of Langerhans, gonads. (Details of histology and biochemistry will not be required.)

(j) The nervous system, limited to the main regions of the brain, the spinal cord, the autonomic system and the sense organs. By comparison of the mammal with organisms mentioned below, a simple study of reflexes, behaviour patterns, rigidity and flexibility of behaviour, play and learning.

(k) The reproductive system and an outline of the development and care of the young.

(l) Cytology. Protoplasm, its physical and chemical nature. The structure of cells.

(m) Histology. The aggregation of cells into tissues and of tissues into organs as illustrated by the skin, small intestine, liver, pancreas, plain and striated muscle, medullated nerve, cartilage, bone, areolar tissue, pavement epithelium, ciliated epithelium, blood, kidney and gonads.

When considering the organization of the mammal it is to be emphasized that the student should study his own body as well as that of the rabbit (or other mammal). He has some acquaintance with the structure, function and even gross physiology of his own body but he cannot dissect it. He can dissect the rabbit but can learn little of its physiology or even its functional morphology under the conditions of a school class. The objective should be to get him to combine the observations made on himself with those made on the rabbit so that he can interpret his structure, etc. in terms of what he learns of the anatomy from the rabbit. He should not be allowed to study the anatomy of the rabbit entirely for its own sake. To attempt to understand one organism by reference to data derived from others is a common procedure in biological research, e.g. the physiologist has interpreted the behaviour of the nervous system in the mammal, including man, largely on the basis of detailed work carried out on the nervous system of the frog.

In teaching the energy changes taking place within the body it should suffice to acquaint the student with the idea that many chemical changes are taking place simultaneously within the cells. Among these, are changes leading to the breakdown of glycogen to lactic acid with the liberation of energy, and complete oxidation of some of this lactic acid which supplies energy for the reconversion of the remaining lactic acid to glycogen.

2. Other animals. (195 periods.) The animals listed below should be examined for their general external features, especially those by means of which they can be assigned to their respective phyla. They should also be examined

in greater detail in respect of points of special morphological and physiological interest, but a detailed study of their comparative anatomy is not required. Living specimen should be examined wherever possible.

A. (a) The following flagellates should be studied with the object of appreciating the difference between plants and animals. Euglena: its general structure and movement. Chlamydomonas: cell walls, sexual reproduction, holophytic nutrition. Polytoma: saprophytic nutrition, comparison with other species. Peranema: holozoic nutrition.

(b) Other Protozoa. Amoeba: protoplasm, nutrition, irritability, movement, function of the contractile vacuole, life-history. Paramecium: as for Amoeba, significance of conjugation. Intracellular complexity in contrast with that of metazoa. Monocystis: its life-history, adaptation to parasitism. The malarial parasite (see also section 4 A).

(c) Hydra: Differentiation and specialization of cells. Reproduction (asexual and sexual). Behaviour. Life-history.

(d) A turbellarian worm: nervous system and behaviour. Regeneration. (Details of the reproductive organs will not be required.)

(e) Ascaris (or Oxyuris or Ankylostoma): life-history and parasitic habit (see also p. 38).

(f) Earthworm: the body cavity, blood system, alimentary canal, nutrition, excretion, nervous system, behaviour, reproduction. Specialization of tissues; organs. Life-history. Economic importance.

(g) Nereis: external features, free larval stage.

(h) Insects: omitting internal structure; feeding without details of individual mouthparts; ecdysis, types of metamorphosis. Cockroach: external features, respiration, excretion, life-history. Butterfly: life-history. Honeybee: social life and economic importance. Mosquito: life-history and economic importance. An aphid: e.g. bean aphis: annual life-cycle, parthenogenesis and economic importance. Housefly (or blowfly): life-history and economic importance (see also section 4 A).

(i) Snail: external features, movements, feeding habits.

(j) Dogfish (from preserved specimen). Vertebrate organization. External features. Life-history.

(k) A teleostean fish: external features, respiration, swim-bladder.

(l) Frog: external features, respiration. The life of the tadpole, its metamorphosis and its transition from aquatic to terrestrial life.

(m) A bird: adaptation to flight. Nesting and care of the young.

The pupil should be able to indicate the characteristics of the animals referred to in this syllabus by means of which they can be placed in the correct segregate of a simple classification such as the following:

Sub-Kingdom Protozoa
Sub-Kingdom Metazoa
Phyla: Coelenterata, Platyhelminthes, Nematoda, Annelida, Arthropoda (with Classes Crustacea, and Insecta), Mollusca, Chordata (with Sub-Phylum Vertebrata and Classes Pisces, Amphibia, Aves and Mammalia).

The tradition of commencing study with Amoeba arose from Haekel's conception of Amoeba as an aboriginal organism which is no longer justified. Amoeba is included for the information it gives about protoplasmic structure, and how animal life can be maintained with the minimum of structural organization. To make clear the position of Amoeba in relation to other living organisms it should be compared with Flagellata and bacteria.

The Flagellata are placed at the beginning of the list of organisms because this group stands between the plant and animal kingdoms. Euglena, unlike most flagellates, is large enough for the student to see its essential microscopic structure (flagellum, eye spot, etc.). Chlamydomonas is a flagellate that exhibits the plant-like characteristic of cellulose cell walls and holophytic nutrition.

Turbellarian worms are easily collected and observations on their reactions, feeding and regeneration can readily be made.

It is desirable that the whole classificatory system of animals should be studied in detail. The object should be to enable the student to place any common animal among its kind. For example, he should be able to recognize that a colony of Obelia, a jelly fish, and a sea anemone are all examples of Coelenterata.

B. In addition to their external features the general anatomy of the following animals should be studied: the rabbit (or rat), frog, dogfish and cockroach (by dissection); the earthworm (by dissection and examination of prepared sections); Hydra (by examination of prepared sections and of squash preparations of cells composing living tissues). The study of mammalian anatomy in this section should be treated in relation to the studies in section 1.

3. Natural history (60 periods.) The natural history of animals specifically mentioned in sections 1 and 2. The natural history either of a common group of animals or of the animals of some well-defined habitat. Such study should include some aspects of the following: food relations, habits, life-histories; adaptations to the physical environment and to other organisms about them.

No restriction will be placed on the group or animals or habitat chosen. (Suitable examples of habitats are: freshwater ponds, streams, marshy ground, the sea-shore, the soil, an oak tree, rubbish heaps. It should be understood that much useful work can be done by studying animals in aquaria and vivaria.)

The objectives of this section are:

(a) To encourage a natural interest in the animals of the world.

(b) To introduce the student to the concept of species, and to base this concept directly on familiarity with animals seen in the field instead of upon theoretical definitions learnt from books.

(c) To enable the student to study the influence of the environment on animals and to appreciate the application of such studies to human affairs.

(d) To train the student in drawing scientific conclusions directly from personal observations he makes and in testing these conclusions by further observations; and to show the advantage of this direct contact with observed fact over a sole reliance on the statements of books and teachers.

The greatest importance is therefore placed on the encouragement of individual field work. Though there are many difficulties, the student should make his own collections and segregate, if not name, the species he collects. The widest choice should be allowed in this subject, and the teacher should assist by indicating subjects which the student can profitably pursue. At the same time projects of too wide a scope must be guarded against; best results will come from careful exploration of a relatively narrow field.

In field work animals may be studied from two points of view. The first is the ecological approach. In this, one or more well-defined habitats are selected, the different animals that occur are ascertained by collecting or (as in case of birds) by carefully recording; and observations are made on the parts they play in the whole community of plants and animals of which they are members. Alternatively, in appropriate cases, a piece of field work having the ecological approach may, quite properly, be concentrated on the study of a single species in a small specialized or physically restricted environment.

The second approach is the systematic one. Here a group is selected, e.g. slugs, wood-lice, ground-beetles, and specimen are collected (or observed in the case of birds, etc.) wherever they are to be found. Specimen collected are carefully labelled to indicate geographical locality (parish, name of place, or national grid reference, etc.), type of environment (e.g. oak wood, heather-moor, sand-dune, etc.), and date of capture, and sometimes other relevant data such as collector's name, altitude, temperature, etc. The specimen are segregated and identified as accurately as possible. Subsequently lists may be compiled of all the places, all the times of the year and varying conditions under which any particular species or group of species is found to occur. Whichever approach is adopted, it is necessary to identify specimen as accurately as possible. This is not an easy task. The botanist has numerous "floras" to select from when he wishes to identify specimen of any of the more prominent groups of the flowering plants and ferns, of which there are some 2,000 British species. The task is much more difficult if he wishes to identify such plants as algae, diatoms, desmids, mosses, fungi, etc., of which there are, perhaps, some 18,000 British species. Works for identification of these are often available but they may be old, in obscure journals, in foreign languages or otherwise inaccessible. The difficulty of identification is magnified many times in zoology; there are at least 20,000 species of British insects alone. The two most prominent groups of insects are, probably, the butterflies (65 British species) and the beetles (3600 British species); books comparable to "Floras" exist for such groups and can be used by those who are prepared to acquire the requisite amount of information on morphology to use the descriptions and keys. Unfortunately, the morphological knowledge required to identify animals is quite different in different groups, e.g. in sea-anemones, star-fishes, crabs, beetles, butterflies, snails, etc. In fact, no single book could be put together that would, like a "Flora," identify all the more conspicuous animals that an assiduous collector might pick up.

A specimen can often be named with apparent ease by comparison with coloured figures of photographs. It is, however, unwise to rely on such a determination unless backed up by comparison with letter-press descriptions in which the salient features for positive identification will be mentioned. It is therefore wise to examine critically the text of any book which makes an initial appeal to the eye by means of coloured plates. Many such books contain excellent textual material; others do not.

The school pupil may well begin by using, in zoology, such books as Mellanby, H., Animal Life in Freshwater, Methuen, and Eales, N. B., The Littoral Fauna of Great Britain, Cambridge University Press, in which the commoner, conspicuous animals in a habitat are noted, perhaps described and figured, but in which there is seldom the means of distinguishing between species when they belong to the less common or less conspicuous groups.

Examples of studies that could be approached from the ecological point of view are: freshwater ponds and streams; selected parts of the sea-shore; insects bred from plant-galls (see Salt, G., 1947, School Science Review, vol. XXIX); insects found in a rubbish heap throughout the year; insects bred from flower heads of Compositae; succession of organisms appearing in a glass of water (covered to prevent evaporation) to which a little mud from a dried-up pond has been added; habits of British reptiles or amphibians occurring locally; habits and ditribution of fishes; habits of earthworms; habits of spiders; experiments with caddis fly larvae (case building), prey of hunting wasp.

An account of an almost perfect example of work involving the ecological approach and dealing with a single species will be found in Neal, E., The Badger, Collins. Possible subjects for work on single species are: observations of the life of a captured wasp or a bumble bee's nest; observations of the life of a fish or reptile in aquarium or vivarium; habits of an out-of-the-way pet such as an owl or an otter; plumage development on nestlings of a species of bird; conditions of climatic factors governing the occurrence throughout the year, of some species of butterfly. Unless a pupil is drawn towards some particular groups of animals it is as well not to choose a group for study from the systematic approach without first making sure that a suitable book or paper is available by means of which the specimen collected can be identified. Slugs, wood-lice and ground-beetles have been cited above as groups suitable for study by the systematic approach. Other groups are: wasps, bumble bees, snails, dragon flies, grasshoppers, water beetles, waterbugs.

The above list of suggestions should not be regarded as in any sense restrictive.

Candidates in the United Kingdom who are specially interested in natural history may offer Field Work as an additional item for examination.

4. The relation of animals to Man. (30-50 periods.)

A. Vectors and parasites. Animals in relation to human hygiene. Malarial parasite and the mosquito. Hookworm. Liver-fluke. Body louse and typhus. Housefly and enteric infections. Features of parasitism.

The study of these forms should be limited to a general account of the life-history of the parasite and of its vector, if it has one; the general effects of the parasite on the host without details of clinical symptoms, and the way in which zoological knowledge has enabled methods of real control to be worked out as distinct from methods of medical treatment of cases.

B. Economic zoology. Farm animals and their relation to food production and agriculture; food fishes; destructive and beneficial insects.

The student should learn to apply his zoological knowledge to problems of everyday life. Most students have a strong natural interest in problems of economic zoology when they come in contact with them and some knowledge of these is unquestionably desirable.

When one considers the economies of dairy farming and milk products it seems reasonable that knowledge of them should be given. Scanty knowledge is no excuse for not discussing biological problems; the future citizen may have to settle them. General problems only should be considered; highly detailed studies are undesirable.

The following is merely a list of examples from which two or three may be chosen with a reference to local conditions or interests.

Domesticated animals:
- Cattle (characteristics of beef, dairy, and dual purpose breeds; variety of other products yielded; feeding of stock.)
- Sheep (distribution, density of population, liver-fluke and blow-fly.)
- Pigs (feeding to suit market, reproduction capacity.)

Food fishes:
- Herring (food chain; herring fisheries.)
- Plaice (over fishing problem.)
- Salmon (migration; fish hatcheries.)

Insect pests:
- Clothes moths (life-history; diet; control.)
- Cabbage butterfly (food plants; migration; natural enemies.)

Beneficial insects:
- Hive and other bees (pollination of fruit blossom.)

While in some cases successful application of biological science to practical affairs can be demonstrated, in others it cannot. A good example is the biological control of greenhouse White-fly in tomato houses by means of the hymenopterous parasite Encarsia. A certain amount is known of the genetics of cattle but while this can be used to explain some of the results of normal selective breeding of cattle it cannot yet be used to provide a programme for the production of a breed of cattle with a particular set of desired characteristics. Some teachers may find that they have amongst their pupils individuals with practical experience of the use of sex-linked characters for the sexing of day-old chicks. Care must be taken to avoid any impression that Mendel's laws can be simply illustrated by breeding together cattle, sheep, etc., with contrasting characteristics.

5. Embryology, Genetics and Evolution.

A. (20 periods.) The knowledge of embryology required is the minimum necessary to build up a general idea of the way in which reproductive cells of the organism are transformed into a new organism of the same pattern as its parents.

(a) Development of the frog's eggs for external features of cleavage (see also section 2 A (1)).

(b) Development of the central nervous system, notochord and coelom and the concept of germ layers, as shown in diagrammatic representations of the development of Amphioxus.

(c) Development of a bird as far as it can be seen with a good hand-lens; structure of the egg and the function of embryonic membranes (but not detailed account of their embryological origins).

(d) A simple account of the development of the rabbit, including the functions of amnion and placenta (but not detailed account of their embryological origins.

The teaching of embryology is not easy. The old but clear story of the origins of tissues is not satisfactory in the light of modern research. Unfortunately, the results of this research are not yet available in a form suitable for teaching in schools, and, even if suitable text-books were available, it would require disproportionately large number of hours to teach it and, probably, only the best pupils could assimilate it.

The external evidence of cleavage in the frog can be seen with a good hand-lens (or better with a low-power binocular microscope).

The development of the structures mentioned under (b) is fundamental to a comprehension of the transformation of the egg into an organism but they are probably best learnt from text-book diagrams rather than by attempting to interpret a whole range of sections of Amphioxus or any other animal. The pupil should, however, have had some experience of interpreting transverse sections of frog and chick in which the structures mentioned can be seen but not of sections where there is complexity due to other organs such as those to be seen in the region of the pharynx, or of the brain.

Candidates should be familiar with whole mounts of chick embryos.

B. (25 periods.) Outline of Mendelian inheritance for not more than two pairs of characters. Mitosis and a simple outline of the behaviour of the nucleus in maturation of the germ cells and in fertilization. The evidence connecting inheritance with chromosomes. Elementary knowledge of linkage and crossing over, sex chromosomes and sex linkages. A knowledge of the importance of the pairing and subsequent separation of homologous chromosomes, and of the haploid and diploid conditions but not a detailed study of meiosis.

An elementary knowledge of genetics is necessary in any elementary biological training, but the subject has progressed so far and so rapidly that, in the absence of suitable textbook treatment, the study of recent developments is impracticable at school. It would require an excessive allotment of teaching time, and the curtailment of other parts of biological knowledge would only add to academic isolation of the genetical study. An arbitrary line has therefore been drawn with the object of excluding the more complex details of meiosis and its genetical significance. An understanding of these things demands an appreciation of physico-chemical models of the chromosomes which are beyond the elementary student.

C. (10-30 periods.) Outline of the concept of evolution and the nature of the evidence for it. The outstanding features of the palaeontological succession. Introduction to the theory of natural selection with reference to variation, mutation, isolation, and the struggle for existence.

At this stage a distinction must be drawn between the undoubted fact of organic evolution and the mechanisms by which it has been brought about. The latter are still the subject of debate among experts and cannot therefore be fully considered in a general school course. The materials and arguments found in the earlier chapters of The Origin of Species are still perhaps the most suited to school pupils. The evidence of palaeontology is not only of major importance but the story of early conditions of life on earth have a fascination of their own. Evidence derived from comparative anatomy and embryology may best be regarded as subsidiary to this. With regard to mechanisms of evolution, scholarship and other particularly apt pupils, especially if they happen to be of a methematical turn of mind, might be introduced to such ideas as those of allometric growth.

The teacher wishing to inquire into the modern trends of the scientific study of animal evolution might refer to: Simpson, G. G., 1950, The Meaning of Evolution, Oxford University Press (a book intended for intelligent non-zoologists), and/or Carter, G. S., 1951, Animal Evolution, Sidgwick and Jackson (intended for zoologists).

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