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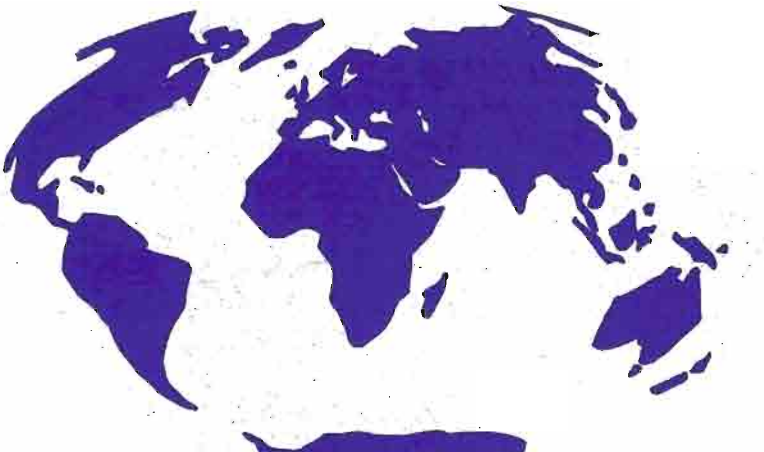

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EDITOR'S NOTE

Almost five years have passed since the International Union of Biological Sciences established its proper scientific programmes, as one major component to be added to the more traditional functions of the Union. We believe there is a need to present some of the very basic facts at this time, which will show the wide range and scope of these activities undertaken by the IUBS.

The IUBS organized 30 scientific meetings (symposia, workshops and training courses), dealing with biological research, management, training and education; in areas ranging from bio-indicators to tropical biology, biocomplexity to biological nomenclature, and marine to mountain ecosystems biology. Parallel to these meetings, the Union produced more than thirty publications, which consist of scientific reports and proposals for collaborative research programmes, published as Special Issues of *Biology International;* monographs and scientific reviews published either as a part of the newly launched IUBS Monograph Series, or in collaboration with international publishers, and finally methodology guides, that will be tested prior to the final publication as a new IUBS Methods Handbook Series.

In the same period, with regard to finances, the IUBS was able to provide more than US $ 570 000 as seed money, which should be multiplied by at least 10, to give an idea of the funds used for the implementation of these programmes.

The major difficulty encountered by the IUBS is to adapt to the constraints imposed by the different time scales; for example, the necessity of needing a «decade» for the planning and implementation of an international collaborative research programme, and having only a one to two-year period, as given by most of the national and international financial donors. More precisely, the challenge being how to collect and collate the many and different pieces of the puzzle into a coherent scientific programme !

Comparative Biology of Neurotransmitter Functions

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Communication between cells is of fundamental importance to multicellular organisms, and it increases in complexity as the organism becomes more differentiated and advanced. Rapid, flexible communication between cells is particularly important in the nervous system, which must constantly receive and process large amounts of information and must control all physiologic processes, as well as the organism's responses to the environment.

As the nervous system evolved, several solutions have developed for the problems associated with transmitting information to other cells. The first problem was how to transmit information over long distances within the body. Part of the solution was an anatomic extension of the neuronal processes. Some individual sensory fibers have processes which project from the distal extremities to the spinal cord — a distance in some animals of several meters. But, anatomic extension alone would not produce a rapid spread of information along the cell. Speed has been achieved by the development of electrical excitability.

A generalized view of a nerve cell is shown in Figure 1a. The essential features of electrical excitability in neurons are illustrated in Figure 1b. (The same process occurs in muscle and many other cell types). Neurons have a resting membrane potential (RMP) of about 50 to 90 mV, inside negative. The RMP results as a consequence of an unequal distribution of ions across the membrane : inside the Cell K^+ is relatively high, while on the outside Na^+, Ca^{2+}, and Cl^- are high (Fig. 1c). The unequal distribution is due in turn to differences in the permeability of the membrane to various ions and to metabolic processes which remove or sequester specific ions from intracellular compartments.

Ions of greatest importance in determining RMP are Na^+ and K^+. The membrane is approximately 10 to 100 times more permeable to K^+ than to Na^+ and contains an active transport mechanism which pumps Na^+ out and brings K^+ into the cell. For each ion one can define an equilibrium potential, E_{ion}, which is the potential at which the electrical and chemical driving forces are opposite but equal. E_{K^+} is near RMP because the membrane is relatively permeable to K^+. Chloride is usually distributed passively, so E_{Cl^-} is even closer to RMP. Because Na^+ and Ca^{2+} are normally excluded from the cell, their equilibrium potentials are much more positive than RMP.

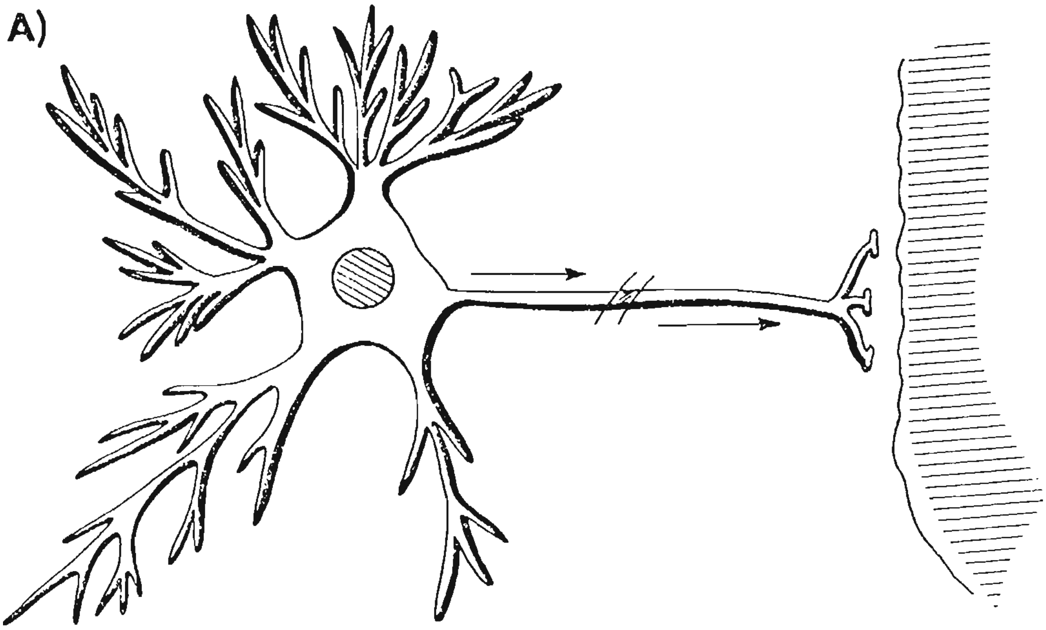
If one specifically increases the permeability to one ion, RMP will move in the direction of the equilibrium potential for that ion. If one decreases the permeability to the same ion, RMP will move away from its equilibrium potential and toward that of the ion to which the membrane is most permeable. This fact is of central importance in understanding transmitter actions, as will be discussed below.

The mechanism underlying electrical excitability is the action potential, an electrical signal of constant amplitude which is normally generated at the cell body and propagates rapidly down the axon. Action potentials are typically of the order of 100 mV in amplitude, last a few milliseconds, and may move at speeds of 120 m/s or more. Like RMP, action potentials result from alterations in ionic permeability. In most excitable celles the rising phase of the action potential is a consequence of a transient but pronounced increase in Na^+ permeability. In other cells the rising phase of the action potential may be due to an increase in Ca^{2+} or a combination of Na^+ and C^{2+} permeabilities. The membrane potential moves in a depolarizing direction because the permeability change causes it to approach E_{Na^+} or $E_{Ca^{2+}}$. However, this permeability increase is short lasting and triggers an increase in K^+ permeability which causes the cell to repolarize.

While the generation of an action potential allows for rapid spread of information within a neuron, it does not create communication between neurons. Most nerve cells are anatomically isolated and electrically insulated from other cells by extracellular space, which the action potential cannot cross. In only a few instances are there specialized junctions between neurons which allow a portion of the potential generated in one neuron to pass directly to the second (Bennett, 1977).

In most cases information is communicated by the process of synaptic transmission. This process is found throughout the animal kingdom, wherever there are multiple nerve cells — that is, from coelenterates to man. The principal aim of this article is to examine some of the important similiarities and differences in the evolutionary stages of this fundamental life process.

A)



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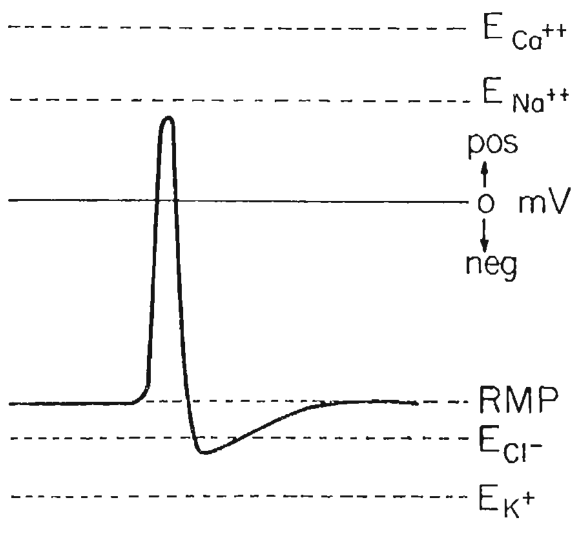

C)

IONIC CONCENTRATIONS (mM) ACROSS NEURONAL MEMBRANES

Marine	In	Out
Na	50	450
K	400	10
Cl	100	340
Ca	10^{-3}	10
LAND/FRESH WATER		
Na	12	145
K	155	4
Cl	4	120
Ca	10^{-4}	4

Figure 1. Transmission of Information within a nerve cell (A). Schematic diagram of a typical neuron. The arrows and shading show the movement of the action potential along the axon (B). Resting membrane potential (RMP) and equilibrium potentials (E) for major ions. (C) Concentrations of significant ions inside and outside of neurons.

Much of our current understanding of synaptic transmission comes from studies of the frog neuromuscular junction, pioneered by Katz and colleagues and elaborated by a variety of laboratories (e.g. Katz, 1969; Rubin, 1974). In the usual interpretation of events (Fig. 2) the presynaptic nerve terminal approaches the postsynaptic cell (in this case, a muscle fiber) but does not make physical or electrical contact with it. The terminal of each neuron synthesizes one or more chemical transmitters (in this case, acetylcholine) and stores them in membrane-bound vesicles. When an action potential is propagated down the presynaptic axon, the contents of a few of these vesicles are released from the terminal.

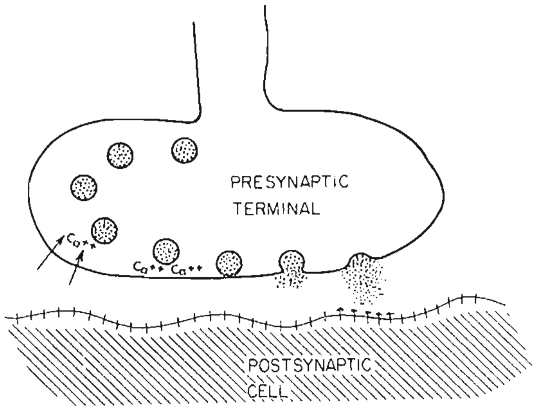

Figure 2. Schematic representation of exocytosis in transmitter release.

The release mechanism requires entry of Ca^{2+} into the cell from external medium. (During an action potential the normal resting impermeability to Ca^{2+} is transiently abolished). The higher concentration of Ca^{2+} in the nerve terminal produces a fusion of the vesicles membranes with the terminal membrane, by a process not totally understood, followed by exocytosis. In exocytosis the transmitter contained in the vesicle is extruded from the cell into the extracellular medium, where it diffuses to reach specific receptor proteins on the postsynaptic cell.

Although there remains some controversy regarding whether or not all transmitter release is vesicular (cf. Israel *et al.*, 1979; Tauc, 1982), the general characteristics of the release mechanism appear to be common for all transmitter substances.

What Substances Are Used as Transmitters ?

To be identified as a neurotransmitter substance, a compound must meet at least five criteria (Table 1). While many substances may be transmitters, not all have been proven to meet all of these criteria. For example, substances which are present in brain and have actions on neurons may be transmitters, but this evidence is not sufficient proof. Such substances are described as "putative neurotransmitters".

The easiest tools available to a neurobiologist at present are those which localize materials in the nervous system and determine the physiologic responses from neurons when the substances are applied. On the basis of these studies a number of small molecules are thought or proven to be neurotransmitters in all animals with a nervous system (Table 2), although there are some differences in the distribution and use of particular transmitters in different species. In mammals acetylcholine, acting at nicotinic receptors, is the exclusive excitatory transmitter onto skeletal muscle. In invertebrates acetylcholine is a principal neuromuscular transmitter in nematods, annelids, and molluscs, but glutamate has this role in crustaceans and insects (Gerschenfeld, 1973). However, a number of other substances also have roles as neuromuscular transmitters. These include dopamine (Swann *et al.*, 1982) and serotonin (Koester *et al.*, 1973) in molluscs, as well as histamine (Droogmans *et al.*, 1977), norepinephrine and ATP (Meldrum and Brunstock, 1983), and some peptides (Bennett, 1975) in mammalian smooth muscle. Other neuromuscular junctions have transmitters which are none of the above substances but have not yet been identified.

Table 1

CRITERIA FOR TRANSMITTER IDENTIFICATION
1. Substance is present in neurons.
2. Substance is released on nerve stimulation.
3. Action of substance mimics that of endogenous transmitter.
4. Mechanism exists for removal or inactivation of substance from extracellular space.
5. Endogenous synaptic response and response to substance have the same profile of pharmacologic sensitivities.

Table 2

COMMON SMALL NEUROTRANSMITTER SUBSTANCES	
Acetylcholine	Dopamine
Histamine	Norepinephrine
Glutamic acid	Octopamine
Aspartic acid	Epinephrine
Glycine	Serotonin
γ -Amino butyric acid (GABA)	

Acetylcholine has transmitter functions at other than neuromuscular junctions in a wide variety of animals. In invertebrates acetylcholine is either excitatory or inhibitory on neurons, and there are pharmacologic dinstinctions related to the ionic response elicited (Kehoe, 1972). Mammals have at least two major classes of acetylcholine receptors; nicotine and muscarine are their respective agonists, and the responses have different pharmacologies. Both classes may be either excitatory or inhibitory.

The amine transmitters are also widely distributed, from coelenterates to mammals. Dopamine, serotonin, and histamine have well-documented roles in all these forms. The role of octopamine is much greater in invertebrates, while that of norepinephrine is greater in mammals (Saavedra and Axelrod, 1976). The synthetic pathways for these related compounds is shown in Fig. 3. The comparative roles of octopamine and norepinephrine are interesting differences in evolution, but they appear to be more a function of the cellular distribution of synthetic enzymes than of lack of enzyme in lower animals. The enzymes which generate octopamine and norepinephrine from their respective precursors, tyrosine and dopamine, are identical; thus octopaminergic neurons must differ from noradrenergic ones in having no tyrosine hydroxylase. The enzyme is clearly present in invertebrates, however, since dopamine exists there and has clear functions. The fact that norepinephrine is low or lacking in most invertebrates must therefore mean that neurons which contain tyrosine hydroxylase do not have dopamine ß hydroxylase. However, dopamine ß hydroxylase must exist in other neurons for synthesis of octopamine. Epinephrine, an o-methylated derivative of norepinephrine, is also much more important in mammals, being either absent or relatively unimportant in invertebrates.

In mammals octopamine is usually considered a "false transmitter" without a primary function, whose synthesis, storage, release, and action at postsynaptic receptors is an accident of its structural similarity to norepinephrine (Kopin *et al.*, 1965).

Amino acids, both excitatory and inhibitory, have important roles in all species with multicellular nervous systems. γ -amino butyric acid (GABA) is probably the principal inhibitory transmitter in all these species (Gerschenfeld, 1973), although it is excitatory at some receptors in invertebrates (Yarowsky and Carpenter, 1978) and activates a receptor in mammals which appears to depress a voltage-sensitive calcium permeability (Simmonds, 1983).

Glycine appears to have a much more important role in vertebrates than invertebrates. Glycine may be equally or more important than GABA as an inhibitory transmitter in the mammalian spinal cord (Curtis *et al.*, 1971), but there are few demonstrations of a transmitter function for glycine in invertebrates, even though some neurons do contain large concentrations (McAdoo *et al.*, 1978).

The excitatory amino acids glutamate and aspartate are, like GABA, important in both invertebrates and vertebrates. In addition to functioning as excitatory neuromuscular transmitters, they elicit a variety of excitatory and inhibitory actions on invertebrate neurons (Yarowsky and Carpenter, 1976). In mammals they are principally excitatory on neurons. It is not yet clear how great a role they play as transmitters. Most transmitters may actually be glutamate — and aspartate-rich peptides, at least in some cases (ffrench-Mullen et al., 1985).

The number of probable or proven transmitters has grown enormously in the past 10 years, particularly as small peptides have been found with transmitter functions. Neuropeptides have been located in both invertebrates and vertebrates, and appear to have important roles even in the simplest nervous system. Frontali and Gainer (1977) have reviewed the known biologically active peptides in invertebrates and reported some 71 substances, many of whose structures have not been determined.

The major known peptides in mammalian brain with documented functions are listed in Table 3. (Numerous other substances have been isolated and proposed to have transmitter actions.) A particularly dramatic feature of about this list is that it contains many substances which have been known for a long time and which have other well-documented functions. Most of the gastrointestinal peptides, for examples, are now known to be present in brain also to affect the electrical acti-

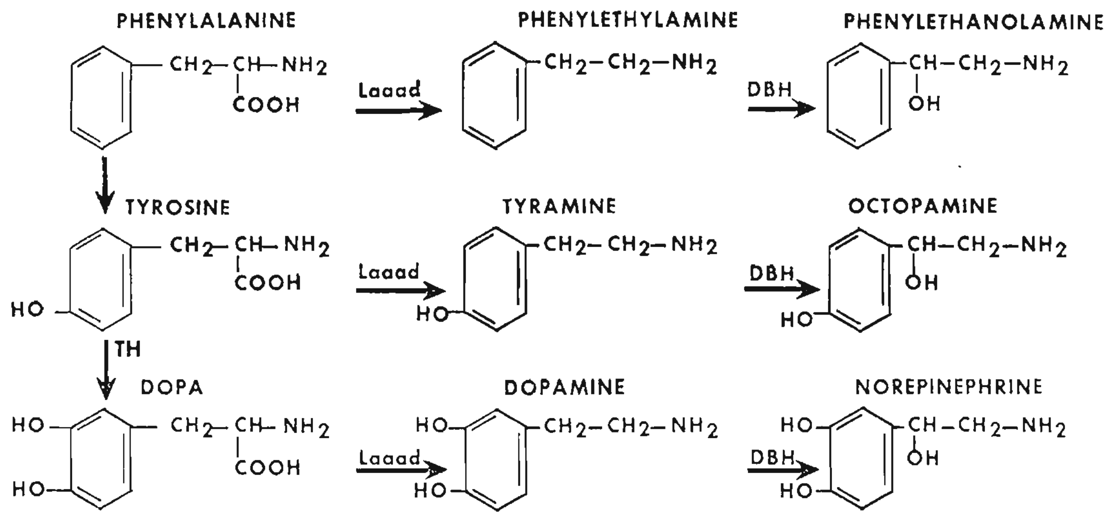

Figure 3. Synthetic pathways for the phenylethyamines and catechloamines. TH = tirosyne hydroxylase; Laaad = L-aromatic amico acid decarboxylases; DBH = dopamine hydroyxlase; DOPA = 3,4 dihydroxy-L-phenylalanime.

Table 3 - MAJOR NEUROPEPTIDES

Peptide	Amino Acid Residues	Documented in Invertebrates	Amphibians	Mammals
Carnosine	2	—	—	yes
Thyrotropin releasing hormone	3	—	Rel	yes
FMRFamide		yes	—	—
Proctolin	5	yes	—	yes
Enkephalins	5	yes	—	yes
Angiotensin II	8	—	Rel	yes
Bradykinin	9	Rel	Rel	yes
Vasopressin/oxytocin	9	Rel	—	yes
Substance P	11	Imm	Rel	yes
Lutinizing hormone releasing hormone	10	—	—	yes
Neurotensin	13	—	Rel	yes
Somatostatin	14	—	—	yes
Bombesin	14	Imm	yes	yes
Gastrin	17	Rel	Rel	yes
Motilin	22	—	—	yes
Secretin	27	—	—	yes
Vasoactive intestinal polypeptide	28	Imm	—	yes
Cholecystokinin	33	Imm	Rel	yes
Neuropeptide Y	36	—	—	yes

Abbreviations : Imm = immunolike reactivity; Rel = related substance present.

vity of some neurons. Although it cannot be proven, a transmitter function for all these substances is very likely to occur.

Other putative transmitters with functions elsewhere in the body are listed in Table 4. These include hormones, steroids, prostaglandins, and purines. Thus a vast number of substances have transmitter functions in the mammalian brain. The number of known transmitters is approaching 100, and probably a great many others have not yet been identified.

Table 4

OTHER PUTATIVE NEUROTRANSMITTERS	
ATP	Prostaglandins
Adenosine	Testosterone
Insulin	β Estradiol
Glucogon	Progesterone
Calcitonin	Glucocorticoids
ACTH	Quinolinic Acid

How Do Transmitters Act ?

Transmitters may act in a variety of ways, most or all which can be understood in terms of changes induced in membrane permeabilities to Na^+, Cl^-, K^+ and Ca^{2+}. The known mechanisms of transmitter action are listed in Table 5.

Usually a given transmitter has only a single type of effect on a specific cell. However, that same transmitter may have different effects on other cells (due to different ionic mechanisms) and frequently a different functional result. Thus a substance that inhibits one neuron may excite another. In some cases a biphasic response on one cell is elicited by a single transmitter (Gerschenfeld, 1973). While this phenomenon is best documented in invertebrates, it appears to occur in mammalian systems as well (Greene and Carpenter, 1985).

Of the variety of mechanisms whereby transmitters may affect neurons, the best understood is fast excitation — a characteristic of the neuromuscular junction in amphibians and mammals, where acetylcholine is the excitatory transmitter. Here acetylcholine causes excitation by opening an ion channel which is permeable to both Na^+ and K^+. The ion channels opened by transmitters eliciting fast excitation in invertebrates appears to be very

Table 5 - TYPE OF PERMEABILITY CHANGES EVOKED BY TRANSMITTERS

Permeability	Documented in		
	Invertebrates	Amphibians	Mammals
P_{Na^+} and P_{K^+}	yes	yes	yes
P_{Na^+} (slow)	yes	—	—
P_{Cl^-}	yes	yes	yes
P_{K^+}	yes	—	yes
$P_{Ca^{2+}}$	yes	yes	yes
P_{Na^+}	yes	—	—
P_{K^+} (rest)	yes	yes	yes
P_{K^+} (M channel)	—	yes	yes
P_{K^+} (Ca^{2+}- activated)	yes	—	yes
$P_{Ca^{2+}}$	yes	yes	yes

similar (Marchais and Ascher, 1979). A transmitter activated Na^+ conductance with somewhat different response times and characteristics has been described in some invertebrate neurons (Gerschenfeld and Paupardin-Tritsch, 1974).

The most frequent mechanism of fast inhibition in all systems is an increase in Cl^- conductance. Since Cl^- conductance. Since Cl^- is usually passively distributed across the cell membrane, its equilibrium potential is near RMP; but the membrane at rest is relatively impermeable to Cl^-. When a transmitter activates a Cl^- permeability increase, there is a shift in the potential, often a hyperpolarization reflecting the slightly negative E_{Cl} relative to RMP. This response is clearly inhibitory. In some cells the value of E_{Cl}— is depolarizing relative to RMP. Chloride responses in such neurons are also inhibitory, principally because the increase in Cl^- conductance reduces the cell's resistance to further input.

This example illustrates the critical importance of neuronal membrane resistance in understanding transmitter actions. Under most circumstances the ions which flow during transmitter actions do not significantly alter the cellular concentration gradients. The potential changes produced by the transmitter action, ΔV, is determined by Ohm's Law : $\Delta V = IR$, where I is the transmitter-induced current and R is the resistance across the membrane. GABA, for example, may be very inhibitory — even when it causes a small depolarization — by virtue of its lowering of membrane resistance. The actions of a second transmitter superimposed on the GABA response would be correspondingly reduced.

While Cl^--dependent inhibition has been known longer, K^+-dependent inhibition is almost equally common in invertebrates and has recently been observed in mammalian neurons (Aghajanian and Lakoski, 1984). K^+-dependent inhibition is characterized by a slower onset and much longer duration than is characteristic of Cl^--dependent inhibition.

More recently recognized are transmitter responses associated with an increase in resistance. These may be either depolarizing (lowering in K^+ permeability; Weight *et al.*, 1979) or hyperpolarizing (lowering in Na^+ permeability; Gerschenfeld and Paupardin-Tritsch, 1974). These responses tend to be quite slow, and by causing an increase in resistance they have pronounced effects on the cell's excitability — effects which are out of proportion to the potential shifts produced. Such actions are still not well understood but clearly occur in a wide variety of neurons. The actions of some receptors to acetylcholine (muscarinic), angiotensin II, and lutenizing hormone releasing hormone (LHRH) elicit a reduction in permeability to a particular K^+ channel (M channel) in a voltage-dependent fashion, and not only regulate neuronal responsiveness to a variety of inputs but also control the duration of neuronal firing in response to inputs (Adams *et al.*, 1982).

Regulation of Ca^{2+} entry into neurons has particular significance, since Ca^{2+} controls such a variety of important cellular functions. Transmitters can either increase or decrease Ca^{2+} permeability in both invertebrates and vertebrates (Hagiwara and Byerly 1981). Since Ca^{2+} currents are voltage-dependent, transmitter actions on Ca^{2+} currents are usually voltage-dependent and may be reflected either in changes in spike duration (reflecting the Ca^{2+} component of the action potential) or in changes in hyperpolarizing potentials (reflecting Ca^{2+}-induced changes in K^+ permeability).

Transmitters also act in important ways to trigger biochemical changes in neurons (Table 6). Many of the electrically mediated transmitter actions discussed above are probably based on these biochemical events, although in most cases

Table 6

BIOCHEMICAL ACTIONS OF TRANSMITTERS
Clyclic AMP
Cyclic AMP
Cyclic GMP
Cyclic GMP
Inositol triphosphate
R ostaglandins
Na^+ Transport

the detailed mechanisms are not yet understood. It is perhaps a statement of faith on the part of an electrophysiologist that all actions on cellular excitability will be reflected in changes in membrane potential and resistance.

The best-studied biochemical effects of transmitters are those which regulate adenylate and guanylate cyclase, both increasing and decreasing the enzymes' activities, thus altering protein phosphorylation and potentially altering ionic permeabilities. Recently inositol triphosphate has been recognized as another important "second messenger" (Berridge and Irvine, 1984). Both the cyclic nucleotide and inositol triphosphate actions involve intracellular Ca^{2+}. Cyclic GMP — and inositol triphosphate — associated events in particular appear to involve a mobilization of intracellular Ca^{2+}, which probably then functions as a second messenger through actions on protein kinase C (Downes, 1983). Other transmitter-activited biochemical changes are less well documented and understood but are not necessarily of any less importance.

It has become popular to distinguish "neurotransmitters" from "modulators" on the basis of the duration of their actions (Iverson, 1984; Shain and Carpenter, 1981). Certainly the actions of some substances, such as the excitatory amino acids, GABA, and acetylcholine, at nicotinic receptors tend to be relatively rapid, while actions of others, such as amines and peptides, often give more prolonged effects. However, a given substance can often cause rapid effects on one system and slow actions on another. Both fast and slow transmitter-induced effects alter the response to a second transmitter, since membrane voltage and conductance are changed. Thus the difference between a rapid effect and a more prolonged action need not imply any distinction between "transmitters" and "modulators" but rather are reflections of the variety of effects that can be elicited by one substance.

Despite the great number of transmitter substances and the variety of their possible actions, one can offer some generalizations on transmitter actions which apply to both invertebrates and vertebrates :

1. Each transmitter substance can trigger a variety of ionic and/or biochemical responses on different neurons. In one study on *Aplysia* neurons Gerschenfeld and Paupardin-Tritsch (1974) found serotonin to elicit fast Na^+, and slow Na^+ Cl^-, and K^+ permeability increases, as well as Na^+ and K^+ permeability decreases. In the same preparation serotonin also stimulated cyclic AMP production (Cedar and Schwartz, 1972) and mediated a Ca^{2+} conductance increase response (Pellmar and Carpenter, 1980). Even GABA, which most commonly elicits a Cl^- conductance increase in all systems studied, has been shown in some systems to reduce resting K^+ conductance (Yarowsky and Carpenter, 1978), reduce adenylate cyclase activity (Wojcik and Neff, 1983), and reduce Ca^{2+} currents (Deisz and Lux, 1985).

2. The types of response to transmitters are relatively independent of the specific transmitter which elicits the response. The nervous system appears to have a variety of building blocks — transmitter receptors on the one hand, ion channels and biochemically activated events on the other — and these blocks are paired in a variety of ways.

3. The process of synaptic transmission has been conserved without fundamental changes in the evolution from coelenterates to man. While there are some differences in the structure of the peptides and perhaps minor differences in the properties of ion channels, the basic mechanisms and its complexities do not differ significantly between invertebrates and mammals.

Of course our knowledge of the nervous system is far from complete, and it is possible, that major evolutionary developments will someday become known. With our present knowledge, however, it is remarkable how little change there has been in the substances used as transmitters and the mechanisms whereby they act. The process of communication between neurons is complex, and the fact that it has not changed in major ways throughout phylogenetic evolution is indicative of how significant a development chemical synaptic transmission was.

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Tropical Ecology : its Beginnings, Specificity and Constraints

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When asked to deliver the inaugural lecture to this Fourth International Congress of Ecology, I felt that some thoughts on the early history, present situation, and foreseeable future of tropical ecology might make a suitable and even timely topic. The International Association for Ecology (INTECOL) has indeed always shown a particular interest in this field, not only because it offers unique scientific opportunities to study fundamental problems, but also because of its potential usefulness to further the economic and social development of Third World countries. Alone or together with the International Society for Tropical Ecology, INTECOL has organized some symposia on the subject in the past. More recently, it sponsored the publication of the new *Journal of Tropical Ecology*, and it actively contributed to the launching of the IUBS' «Decade of the Tropics».

Furthermore, the early history of tropical ecology has not attracted much attention up to now. The matter is seldom if ever mentioned in most of the recent books and papers dealing with the history of ecology as a whole. Yet, many of the pioneers of ecological research overseas were «out of the ordinary» people, compelled to work under conditions we now have some difficulty in imagining. I therefore felt that it was appropriate to pay a tribute to some of their more remarkable achievements.

The Beginnings of Tropical Ecology

Gilbert White is often considered as the examplary representative «proto-ecologist» of the eighteenth century. His *Natural History of Selborne,* based upon observations carried out from 1767 to 1797 in his native parrish delighted generations of nature lovers and set a standard for thousands of field-naturalists in England and elsewhere. Thirty-two years earlier, however, the first and unfortunately single volume of the *Histoire Naturelle du Sénégal* was published, a book written by Michel Adanson, a well-known botanist (Linneaeus named the Baobab *Adansonia* after him) and malacologist, but also a field-man whose mind was as «active and inquisitive» as that of the Rector of Selborne. Adanson stayed in Senegal from 1749 to 1753, the majority of this period spent in what is now known as the city of Saint Louis. He not only collected plants and molluscs, but also made the first scientific observations on the natural history of the lower Senegal valley. The first 190 pages of his very lively book tell the story of his travels and team with fascinating observations. Was he not, for instance, the first to record the wintering of European swallows in West Africa, the aestivation of the local hedgehog, and to establish by experiment the electric nature of the discharge of the African electric eel ? Nothing escaped his inquiring mind; climate, soils and geomorphology, vegetation, fauna or native customs. His description of the westernmost part of the Sahel makes most interesting reading even two centuries later.

The next proto-ecologist of note was unquestionably Alexander von Humboldt. During his travels in Venezuela, Columbia and Ecuador between 1799 and 1803, he was particularly impressed by the relationships between climate and vegetation. By systematically tabulating his geographical, meteorological and botanical data he laid the foundation for ecological plant geography *(Essai sur la Géographie des Plantes;* 1805). His famous profile of the Chimborazo illustrates for the first time the altitudinal zonation of vegetation in a tropical mountain. It is also to one of Humboldt's protégés, Jean-Baptiste Boussingault, that we owe the first hint of the importance of nitrogen in what we now call primary production. Travelling in Venezuela, Colombia, and Peru between 1822 and 1832, as a mining engineer, he was impressed by the lush growth of crops raised by the local indians in the sterile sandy soils of Peru, through the application of *calliche,* a locally mined impure sodium nitrate, or by the use of seabirds' guano rich in amonium salts. Back in Europe, Boussingault devoted most of his life to the study of the nitrogen cycle, and is presently considered, with Justus von Liebig, as the founder of organic chemistry (McCosh, 1984).

However, extensive travels are generally not propitious to «in depth» ecological investigations which require prolonged periods of observation at a given place. This was hardly possible at the beginning of the nineteenth century, due to the conditions (sanitary as much as political) prevailing in most tropical countries. Very few naturalists were therefore able to stay in the field outside large settlements long enough. Even those on board surveying ships were not often given the opportunity to stay on land for very long by their captains. Charles Darwin himself was not allowed to spend more than six months ashore in tropical countries during the five year duration of the circumnavigation of the «Beagle». That such short visits might have exerted such a decisive influence on Darwin's thoughts give the full measure of his unusual gift of observation and intuitive skill.

Furthermore, many of the first travelling naturalists were not sent into the wilderness of South America or to the East Indies by scientific institutions. They left upon their own initiative and often had to support themselves by collecting and selling specimens to wealthy amateurs or public museums and herbaria. Such was the case for Henry Walter Bates, Richard Spruce and Alfred Russel Wallace, among others. But the very fact they were obliged to be based at a same place for long periods allowed them to learn a great deal more of the local ecology than itinerant collectors did. During his ten years of travelling in Amazonia (1848-1859), Bates, for instance, stayed for 4 1/2 years at and around Ega (now Tefé) where he made his major discovery, that of insect mimicry (Bates; 1862), that most compelling evidence that community patterns are more than just «random noise», to quote Lawrence Gilbert (1983). Another case in point is that of Wallace, whose long expeditions to the Rio Negro and the Uaupes (1848-1852) and to the Malay Archipelago (1854-1862) were a landmark in natural history exploration. Everyone is familiar with his seminal contribution to the theory of natural selection, but his books on the geographical distribution of animals, tropical nature and island life also contributed a great deal to what we now call tropical ecology.

Up until this period however, no serious attempt had been made to describe the structure and to understand the functioning of what we now call a tropical plant community. A major step forward was taken in 1863 when a young Danish college student, Johannes Warming, arrived in Brazil to help his fellow countryman, Wilhelm Lund in his palaeontological excavations at Lagoa Santa in Minas Gerais. Warming was to work there for the next three years, botanizing and studying vegetation during his free time. Alone and on foot, he worked in what could be considered a very modern way, describing the various types of *cerrado* vegetation, the life-forms of plants and their proportion in each community, their phenology and their relation to drought and fire. He also studied forest regeneration and old-field succession. He was the first to adopt a quantitative approach, enumerating, for example, the number of species and individual trees present on sample plots, and discussing the roles of climate, soils and geomorphology. This led to the publication almost thirty years later (1892), of a monograph *Lagoa Santa, Et Bidrag til den biologiske Plantegeografi,* which R.J. Goodland (1975) rightly considers as a paradigm of ecological study. Unfortunately, this contribution had a limited readership, being written in Danish and never translated either in German or English. Only a reprint of the 1908 Portuguese translation is presently available, to my knowledge.

It was also during the second half of the nineteenth century that a number of tropical field naturalists became interested in plant-animal interactions. Some of them were botanical explorers, like Richard Spruce who, from 1849 to 1864 travelled in the Amazonian basin and the Andes, and Odoardo Beccari who explored the Malay Archipelago, from Borneo to New Guinea, between 1865 and 1878. Others were zoologists, like Fritz Müller, a young German who emigrated in 1852 to Brazil, or Thomas Belt, a British mining manager who spent almost five years in Nicaragua between 1868 and 1872. Unfortunately, with the exception of Belt who published his famous *Naturalist in Nicaragua* in 1874, none of the others were easy writers. For instance, Spruce's observations were published long after his death by his friend, Wallace, and Beccari's *Nelle Foreste di Borneo* appeared only in 1902, being translated into English in 1904, but not reprinted since that date. All these volumes are full of exciting observations and interesting suggestions, which sometimes foreshadow some of the most fashionable theories of present day ecologists. Fritz Müller (1879, 1880) is now mostly remembered for his discovery of Müllerian mimicry, but he was also the first to describe the ant-*Cecropia* mutualism. Belt's observations on ant-acacias relationships are often quoted, but Beccari's contribution on Malaysian and Papuan ant-plants (1884-1886) is seldom mentioned. His *Nelle Foreste* is better known, as it abounds with original remarks on subjects as varied as the rather rapid turnover of many rainforest trees, the mechanisms of seed dispersal, the importance of fig-trees in tropical forests, the biology of carnivorous plants, and even the origin of fossil carbon in the humid tropics. This book still remains a treasure of tropical botany, to quote Pichi-Sermoli and van Steenis (1983).

A second turning point in the early history of tropical ecology was taken in 1880, when Melchior Treub was appointed director of the botanical gardens at Buitenzorg, now Bogor, in the island of Java. The gardens were established as early as 1817, and were already well known as a base for the « Natural History Commission of the Dutch Indies », but Treub rapidly turned them into the first permanent biological research center in the tropics. Thanks to the creation of a « Foreigners laboratory » in 1884, Buitenzorg soon became the Mecca for practically all tropical botanists during more than half a century, attracting many continental Europeans interested in pure and applied tropical botany. It is impossible to list, even briefly, all the resident and visiting scientists who worked at the *'s-Lands Plantentuin,* contributing important papers to its famous *Annales.* Among the topics of particular interest to ecologists, mention has to be made of those dealing with the determinants of plant growth in tropical climates, flowering periodicity, role of mycorrhizae and symbiotic bacteria, ant-plants, and animal pollination. Many of the studies of plant physiology carried out at Buitenzorg had also a definite ecological flavour, e.g., those on mangrove trees and epiphytes. Further details can be found in Went and Went (1945). But Treub was also as much interested in what we now call « development » as he was in pure science. Not only did he set up a number of experimental stations specializing in research on particular crops, but he established in 1905 a Department of Agriculture that was considered to be the best in all the tropical world up until the Second World War. Unfortunately, most of the work done at Buitenzorg is ignored by the new generations of scientists, many of whom tend to consider that what is not published in English is not worth reading.

The only other tropical research field station in operation before the First World War was the Biologische-landwirtschaftliche Versuchstation of Amani, German East Africa (now Tanzania). It was opened much later than Buitenzorg, in 1902, and was much smaller, but it served as a base to many naturalists and agronomists. Heinrich Walter himself worked there in the 1930's. Amani was only one of the German scientific achievements in their colonial territories. German botanists played a particularly important role in the field of African plant geography, with the work of Adolf Engler and his associates. Engler himself paid three visits to East Africa (1902-03, 1905, 1913), and his *Die Pflanzenwelt Afrikas* (1908-1925) remains a landmark in the study of African vegetation.

During the same period (1880-1940) two other categories of scientists contributed a great deal to the progress of tropical ecology : medical and veterinary entomologists on the one hand, tropical foresters and « government botanists » on the other. Neither were generally academic scientists, but « applied biologists » working for colonial administrations in Asia and Africa. Their objective was not basic science, but rather more practical goals, such as to solve public health problems, and to improve tropical forestry and agriculture. Their major contribution to ecology was to highlight the complexity of the intricate web of biotic interactions so characteristic of most tropical communities.

They were also among the first to develop methods for the study of insect populations and communities in natural conditions. For instance, a cursory glance through the pages of Hale Carpenter's book *A Naturalist on Lake Victoria* (1920) shows that the first attempts to mark individual tsetse flies were carried out in the East African bush between 1911 and 1914. Later on, more elaborate marking techniques were devised, and the capture-recapture method was widely used to study tsetse populations (Jackson, 1933). It was also Hale Carpenter who, fascinated by the mimetic relationships between *Pseudacraea* mimics and *Planema* models, started sampling butterfly communities at a number of sites in East Africa. In so doing he was able to demonstrate that, at each locality, the predominant mimetic morph was that which copied the most numerous model species. Another example of an important discovery made by tsetse entomologists is that of trophallaxis by Emile Roubaud in 1916. Besides his own work on the tsetse natural history, Roubaud carried out important investigations on the biology of solitary and social wasps in West Africa between 1906 and 1913, and he was the first to suspect the importance of liquid food exchanges in social insects. Another recurrent theme among the publications of this period was again that of plant-animal relationships; for instance those of Andreas Schimper (1888) on neotropical ant-plants, of Alfred Möller (1893) on neotropical fungus-growing ants, and the thesis of Clodomiro Picado (1913) on the fauna of the tank bromeliads of Costa Rica.

Meanwhile, botanists and foresters started to address questions about the community structure of tropical rainforests. In an almost forgotten paper entitled « La fôret vierge équatoriale comme association », written in 1908 just before he left Java for good, Melchior Treub compared the structure of a 40-year-old plantation of a native tree near Tjibodas, with that of the neighbouring primaeval rainforest. He concluded that a natural rainforest in the tropics was not a random assemblage of plant species, but a true « community » where the various participants « cooperated » with each other. He spoke of an unstable plant society (« une société non immuable ») characterized by « coexistence with mutualism ». He claimed that it was not only competition that structured tropical rainforest plant communities, but also mutual interactions. Nothing is ever new under the sun ! Later on, some foresters such as T.F. Chipp (1927) attempted to apply phytosociological concepts to tropical rainforests, without much success however. It was not until 1938 that another tropical forester, André Aubreville, advocated the mosaic or cyclical theory of rainforest regeneration.

Between the two world wars, another important landmark in the development of tropical ecology was taken when an « Institute for Research in Tropical America » was established in 1923 on the island of Barro Colorado, Panama, by the U.S. National Research Council, at the initiative of Thomas Barbour. Since then, the 15 km^2 of this artificial island have been studied by hundreds of biologists, and its forest became the most intensively studied of the tropical world. It was also there that Clarence Ray Carpenter made his seminal observations (1931-1933) on the ecology of Howler monkeys, laying the foundations of modern field primatology (Carpenter, 1934). Unfortunately, no equivalent station was established during the 1920's and 1930's in Asia and Africa. Mention however, should be made of the research activities carried out in peninsular Malaya by the Singapore Botanical Garden and the Forest Research Institute at Kepong. In Africa, the Institut des Parcs Nationaux du Congo Belge was founded in 1934 to promote the biological exploration of the magnificent network of nature reserves of the then Belgian Congo. At about the same time, some of the biology departments of the newly established universities of Eastern and Southern Africa were able to initiate some ecological field work, but the Second World War soon put an end to these early initiatives.

Whereas limnology played a crucial role in the maturation of ecological thinking in temperate countries, this was not the case in the tropics. The first major limnological undertaking was that of August Thienemann and Franz Ruttner, who led a German expedition to the tropical lakes of the Dutch East Indies in 1928-1929. Their work was largely descriptive, but one important result was nevertheless to show the limited value of the contemporary classification of lake types based on studies in Europe and North America.

In a similar way, although coral reefs had attracted the attention of naturalists since Darwin's days, the rapid progress made in the study of the structure and functioning of this complex community had almost to wait until the invention of the aqualung in the 1940's. Alfred Goldsborough Mayor (1918) was apparently the first to study the abundance and association of corals along transects on Murray Island, Australia. He belonged to the Department of Marine Biology of the Carnegie Institution of Washington, whose Tortugas Laboratory had also the privilege of being the first to use a diving helmet to observe, collect and photograph tropical marine organisms. Here, William J. Longley made his pioneer observations on coral reef fishes as early as 1915 (Gudger, 1918). His example was only followed by a few biologists, mainly by H. Verwey (1930b) in Java, among others. Even the famous « Great Barrier Reef Expedition, 1928-1929 » of the British Museum (Natural History) dit not make use of diving helmets. It was not until the 1950's that aqualungs provided marine biologists with a simple way to study the reefs at first hand, giving an unprecedented impetus to coral reef ecology.

The mangroves, the other major ecosystem type of tropical shores, were first studied by botanists, plant physiologists and foresters in South East Asia (Karsten, 1891; Brown & Fischer, 1920; Watson, 1928). However, it was not until 1940 that the first truly ecological study of a mangrove plant community was published by John Davis Jr., working in Florida. Whereas the ecology of some of the characteristic animal dwellers of mangrove was studied earlier, e.g., that of the crabs by J. Verwey (1930a) in Java, the first quantitative sampling of the fauna was not carried out until the 1950's (Sebastian Gerlach, 1958) in Brazil.

It can therefore no longer be doubted that ecology started to develop as early in the tropics as in temperate countries. But its progress was hampered by a number of specific constraints : difficulty of access, health hazards (do not miss a visit to the « botanists graveyard » when at Bogor !), lack of support and isolation from the academic establishment at home, and last but not least, the difficulty of identifying most species of tropical plants and animals. In spite of everything, important discoveries were made by these pioneers. If it may seem somewhat excessive to claim a tropical origin for ecology as R.J. Goodland (1965) did, it is also scarcely realistic to contend, as did P.W. Richards (1963) that « little ecological work was done in the tropics until the late 1920's ».

I will not pursue this brief historical overview any further. What happened since 1945 is familiar to most of us. Suffice it to say that interest in tropical ecology grew progressively as the access to overseas countries became easier with the advent of air travel, and as local working conditions improved. The burgeoning of new universities in the developing countries provided young biologists with fresh opportunities to work on a variety of problems. Furthermore, the general acceptance of the ecosystem concept gave rise, in the 1960's and afterwards, to a few interdisciplinary research programmes (for instance, the International Biological Programme of ICSU, and the Man and Biosphere Programme of UNESCO) that increased the detailed knowledge of at least a handful of tropical study sites.

The Specificity of Tropical Ecology

The interest in tropical ecology reached its climax the 1960's and the early 1970's, when a great deal research was carried out in Africa and South East Asia, and new research institutions became operational in the neotropics. Sadly, this fortunate situation did not last for very long. From the late 1970's onwards, it became more and more difficult for European and North American scientists to raise funds to support overseas research programmes, and a decline in the number of theses and scientific papers dealing with tropical ecology became noticeable (Cole, 1984). The unsettled economic and political situation of many tropical countries created further problems, and the advisability of pursuing research in tropical biology was even openly questioned by some science administrators. Such questions as : « Is it still worth continuing our research efforts in the tropics »; or « Does not nature operate the same way in the tropics as in temperate latitudes, hence, why not concentrate on research at home ? » were openly asked. Fortunately, answers were quickly provided by a number of « high caliber » scientific bodies, such as the National Science Foundation (NSF, 1980). Their impact was unfortunately, not as great as it had been expected, and a Congress such as ours provides an excellent opportunity to emphasize again, both the scientific rationale for increasing our research efforts in tropical ecology, and the socio-economic motives for doing it quickly.

The first question at issue is : has tropical ecology an heuristic value ? The answer is unquestionably, yes. There are many environmental situations in the tropics that have no true counterparts at higher latitudes, and there are many ecological problems specific to these zones that call for innovative research in the tropics themselves. Without trying to be exhaustive, let us briefly consider two of them.

First of all, species diversity. Two-thirds, if not three-fourths of the living organisms are now confined to inter-tropical latitudes, particularly the humid tropics. There are more species of most taxa in these regions, although there are some exceptions to this, such as the earthworms, some groups of entomophagous parasitoids and, possibly, freshwater invertebrates. Furthermore, most of the species of animals found in lowland rainforest and coral reefs are scarce and often sparsely distributed. For instance, 79 to 85 % of the 361 bird species observed by Thiollay (1985) at three rainforest sites in French Guiana appeared in less than 5 % of the sample counts; one percent only were common, and the rest regular with moderate densities. In the two coral reef fish communities studied by Harmelin-Vivien (1986), 85 % of the fish species represented 1 % or less of the community members.

Does, in such cases, each species fill its own narrow ecological niche, or do members of a same guild share the same food resources but avoid competition because of their low numbers ? If this is indeed the case, it remains to be established why they are so rare. Is it because of a strong predation pressure, as supposed by McArthur (1972) and many others, or because some other niche parameters are more limiting than food (microclimatic conditions, availability of adequate breeding or roosting sites, for example). Only detailed quantitative observations, pursued long enough can answer such questions. The detailed life histories and precise ecological requirements of most plant and animal species of the tropics still remain largely unknown, and the differences between the broad taxonomic categories have not often been sufficiently emphasized. For instance, rainforest amphibians are merely moisture sensitive, whereas reptiles respond more to changes in temperature; accordingly, the two groups are influenced differently by environmental gradients (Heathwole, 1983).

In temperate and high latitude communities, the situation is quite different. The plant and animal species which entered these areas had long been selected for their ability to thrive in species-poor ecosystems, where climatic and edaphic conditions are far more important than biotic controls. Therefore, the ecological concepts and ideas appropriate to the study of temperate ecosystems do not necessarily apply to tropical environments.

Another point which needs to be thoroughly studied is that of the nature and relative importance of biotic interactions within tropical ecosystems. Obviously, the more species in a community, the more numerous and often subtle will be their interactions. But the kinds and strength of these interactions may differ considerably according to the organisms concerned, and the structure of the sub-sytems. The matter did not escape the attention of the pioneers of tropical biology, as already mentioned. As early as 1908, Treub complained that not enough importance had been attached to mutualistic relationships. Indeed, the latter seem extremely frequent in rainforest and coral reef communities. Many of them are obligate, others facultative but regular. This contrasts with the situation prevalent in temperate and high latitude ecosystems, where mutualism is far less frequent, and only seldom obligate. But besides competition and mutualism, there are many other kinds of interactions that need to be properly investigated, and their functions quantified whenever possible. For example, the actual role of parasites and pathogens. Is the parasite load of plant and animal host populations higher in tropical conditions than elsewhere ? The answer is apparently yes, at least in vertebrates. For instance, species diversity of monogenean ectoparasites of fish increases towards the tropics, and most microhabitats utilized by tropical parasites remain empty on fish in cold seas (Rohde, 1976). However, care should be taken not to generalize too quickly; what may be true for one kind of organism may well be wrong for another. For example, parasitism seems much more common than predation among insects (Price, 1980). Other types of interaction, such as amensalism, commensalism or even neutralism, should also receive increased attention. Only a better assessment in field conditions of the relative importance of each type of interaction will allow theoretical studies to address more realistic models. The study of tropical ecology is the best antidote against premature generalizations and harmful oversimplifications.

As for the socio-economic motives to increase the pace and the amount of research in tropical ecology, they are many. They have been put forward repeatedly. I only want to emphasize here that we are quickly running short of time. The situation of many tropical countries becomes more critical every year. They are presently facing both a human population explosion and a severe food crisis, whereas the amount of unused arable land becomes more and more restricted. It is becoming a moral duty for all of us, ecologists, to help find some solutions to this issue. In the past, many ambitious development plans, often based on direct transfer of technology from industrialized countries, ended in failure, if not disaster. We do know that, in a number of cases, such fiascos were foreseeable, as the policies proposed did not take into account the specific ecological conditions of the countries concerned. Obviously, there has been a lack of communication, if not of understanding, between agronomists, engineers, decision makers and ecologists. Despite the efforts of a number of international agencies (UNEP, UNESCO, FAO) and non-governmental organizations such as ICSU, planners far too often still consider ecology as a « negative » discipline, more interested in maintaining the *status quo* than providing a scientific basis for socio-economic development. Indeed, it is unfortunately true that many of us in the past showed only scant interest in issues of considerable economic importance, but this is fortunately no longer the case. Most tropical ecologists are now quite aware of their responsibilities, and ready to face them. This is why I will call on all those who are able to contribute to the IUBS « Decade of the Tropics » projects (Swift, 1985). Research programmes on areas such as those on « Tropical Soil Biology and Fertility » (Swift, 1985), or « Responses of Savannas to Stress and Disturbance » (Frost, *et al.*, 1986), are as important for development planners as they are for basic scientists. Both programmes aim at elucidating ecological processes that are far from being fully understood, and also to develop a predictive understanding of the ways in which soil and vegetation respond to various management practices. In so doing, basic science can effectively contribute to development.

Some Constraints to the Development of Tropical Ecology

Fascinating problems of tropical ecology are many, and there is no dearth of able young biologists ready to devote their talents to solve them. Unfortunately, the opportunities to carry out ecologycal research in the tropics are presently dwindling, at the very time when more research is urgently needed. Granting-agencies in industrialized countries are more and more reluctant to commit themselves to the long-term funding of the kind of projects necessary to get results of lasting value. Some agencies even feel that such research projects are now becoming outdated, as modern satellites will very soon be able to provide any kind of information needed about « the environment », anywhere on our planet. On the other hand, tropical governments themselves very seldom consider research programmes in tropical biology worthy of being given priority; short-term « development », or even survival, is their only major concern, and most of them neither have the scientific manpower, nor the research structures, necessary to carry out modern ecological research. What then can be done to improve such a situation ?

First of all, it must clearly be stated that the most sophisticated satellites will never be able to tackle most of the problems raised by the functioning of complex tropical ecosystems. They are able to register and monitor a number of physical and chemical parameters of the global environment, many of them of great biological importance. They can also monitor changes in distribution of forest cover or crop types on land, as well as of phytoplancton at sea. But they will never be able to provide information on the many subtle biotic interactions taking place between the thousands of organisms living in a rainforest or a coral reef. How could satellites help us unravel the relationships between soil organisms, between plants and their pollinators, or between parasites and their hosts ? Such studies will ever need to be done by well trained ecologists, based in the tropics and benefitting from adequate working conditions. Ground studies will always be necessary, not only to validate and interpret the results of satellite investigations, but also to study the many biological processes operating at all levels of integration of tropical biotic communities.

Second, every effort should be exerted to convince both our science policy makers and the local governments concerned, of the critical importance of selecting and maintaining a representative sample of study areas all over the tropics. At first sight, the point might look of secundary importance, but it is actually crucial. Real progress in our understanding of some tropical ecosystems may require 5 to 20 years of baseline data to characterize the complexity of some ecological interactions (di Castri & Hadley, 1985). Such permanent study sites must be efficiently protected (not only on paper) to ensure the repeatability of measurements in time. This implies a sustained, and often locally unpopular, gouvernmental effort, and past experience does not allow much optimism for the immediate future in this matter. Many of the field-stations that were in operation during and immediately after the IBP decade are no longer in use or understaffed, and the future of others is not presently very bright. It is to be feared that the situation will remain insecure as long as more developing countries will not become convinced of the pivotal role that ecological research can play to further their own long-term economic development, particularly in the fields of agriculture, forestry, fisheries, and public health.

Third, there is an urgent need to increase the number of practicing ecologists, professional as well as semi-professional (such as foresters, plant pathologists, agricultural and medical entomologists, fishery specialists, etc.) in most tropical countries. As the number of expatriate scientists will, no doubt, continue to decline over the coming years, it is urgent for nationals to take over research responsibilities from them. It is highly desirable that most of their training be done in the tropics, rather than in temperate countries. This is all the more possible since there are nowadays a number of tropical research centers where training can be carried out in excellent conditions, with the help of foreign consultants, if and when necessary. Cooperative training programmes, such as the course in tropical biology given in Costa Rica by the Organization for Tropical Studies, or the training courses and workshops run by BIOTROP at Bogor, provide excellent examples of what could be done elsewhere.

We can no longer be satisfied with a mere « sit and wait » attitude. We must never forget that we are presently engaged in a race against time. The tropics, and more particularly the humid tropics, are undergoing drastic environmental changes, and their native biota are facing a period of mass extinction, whose biological, economic, and societal consequences might become disastrous. Let us hope that the community of ecologists, and INTECOL particularly, will take up the challenge, and take action before it is too late.

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Call for Nominations for New Members of the International Comission on Zoological Nomenclature.

The following members of the Commission reach the end of their terms of service at the close of the XXIII General Assembly of the International Union of Biological Sciences to be held in Canberra in October 1988 : Prof Dr R. Alvarado (Spain; specialist field Echinodermata); Dr G. Bernardi (France; Lepidoptera); Prof C. Dupuis (France; Heteroptera) and Dr L.B. Holthuis (The Netherlands; Crustacea). A further vacancy arises from the death of Prof B.S. Zheng (People's Republic of China; Ichthyology).

The addresses and specialist fields of the present members of the Commission may be found in the *Bulletin of Zoological Nomenclature,* 44(1) : 2-3 (March 1987). Under Article 3b of the Commission's Constitution a member whose term of service has terminated is not eligible for immediate re-election unless the Council of the Commission has decided to the contrary.

The Commission now invites nominations, by any person or institution of candidates for membership. Article 2b of the Constitution prescribes that :

« The members of the Commission shall be eminent scientists, irrespective of nationality, with a distinguished record in any branch of zoology, who are known to have an interest in zoological nomenclature ».

(It should be noted that « zoology » here includes the applied biological sciences (medecine, agriculture, etc.) which use zoological names).

Nominations, giving the dates of birth, nationality and qualifications (by the criteria mentioned above) of each candidate should be sent by 31 March 1988 to : *The Executive Secretary, International Commission on Zoological Nomenclature, c/o British Museum (Natural History), Cromwell Road, London, SW7 5BD, U.K.*

Shifting Agriculture and Rain Forest Ecosystem Management

By

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Tropical rain forests constitute an important world heritage for future prosperity of mankind for food, timber, fibre, medicine, etc. These forests are rapidly being converted because of timber extraction, shifting agriculture and other «developmental» activities in the region.

Shifting Agriculture and Rain Forests

In India, tropical rain forests occur chiefly in Western Ghats in Peninsular India and in the north-east. Shifting agriculture (locally called jhum) is a major land use, where the farmer shifts from one place to another, after slash and burn and cropping for a year or two. These jhums cycle (intervening natural fallow phase between two successive croppings) has come down to 4-5 years in recent past, from a more favourable 20 years or longer. Because of this, there has been a take-over of forested land by exotic weeds and in extreme cases desertification of vast tracts of land as has happened in north-east India. Cherrapunji, the wettest spot of the world with 1125 cm annual rainfall going upto 2250cm in an exceptional year is an extreme example of a «wet desert».

However, a 10-year jhum cycle has been found to be both ecologically and economically viable. This land use system is based upon efficient recycling of resources, their optimal use and many other ecological principles. In fact, man has not been able to come up with a more efficient way of recovering soil fertility through modern technique than what nature has been able to achieve through the fallow phase. Therefore shifting agriculture has to be the focal point for development and management of rain forests, rather than aging for terrace cultivation based on heavy input of fertilizers, suggested as an alternative by planners and rejected by the jhum farmer.

Developmental Strategies and Rain Forest Management

A total shift to plantation/horticultural crops which would ensure permanent plant cover along with forestry, and with cereal cultivation confined and intensified in the valley lands, would be the ideal alternative for hill slopes of the humid tropics. This, however, can not be realized in the near future, in northeast India. Therefore, for the immediate future, jhum has to be the focal point for development. With a 10-year jhum cycle being ecologically and economically viable, as shown through many of our studies, there is much scope for modifications of the system. Thus, the fallow regeneration could be accelerated through introduction of fast growing native trees into the jhum plots. If they are legumes or non-legumes such as alder (*Alnus nepalensis* in the northeast India), then the recovery of the soil fertility would be faster. These trees could also partly meet the fuel wood needs of the village community, apart from that through social forestry systems using fast growing native trees organized within the village boundry. Organization of horticulture and plantation crops on a cooperative basis considering the family in a village as the unit and with a number of villages covering an area of 100 to 200 ha would ensure maintenance of independent family units and economic viability, and at the same time take the pressure off the land for jhum. This in turn would enable a viable longer jhum cycle of 10 years or more. The northeastern region of India, for exemple, could support a variety of tropical and temperate fruit trees, besides plantation crops such as coffee and rubber. Agroforestry with emphasis on forest-based crops such as cardamum, black pepper and many medicinal and aromatic plants could be considered, depending upon the site conditions. Along with these, facilities could be created around a cluster of villages for semi-processing of the produce before it is transported to the city centre for final processing and distribution.

Improvement and better management of animal husbandry available in the region could meet the protein needs of the community and also provide additional income through export. In the north-eastern region, for example, swine husbandry, which is an integral part of the jhum system offers much scope for improvement. In fact, swine husbandry is an integral part of the shifting agricultural system in many parts of the world, because of its ecological efficiency based on efficient recycling of resources from the jhum system. Poultry and cattle (where it is ecologically viable and already a part of the traditional animal husbandry practise) also offer a largo scope for development using better breeds.

Low level technology introduced into the village units may be to alleviate drudgery such as better implements for shifting agriculture or to improve fuel wood use efficiency through energy efficient stoves or to create energy through minor micro-hydel projects, or through unconventional sources such as solar power or wind power. Artisanal skills such as leather technology, black-smithy or wood and bamboo works could also be developed. All these economic activities would help in conserving rain forests by taking the pressure off this important natural resource.

Rain Forest Restoration Strategies

Based on our studies on tree growth and architecture, we have been able to identify fast growing and otherwise suitable tree species for agroforestry and social forestry programmes for villages in the humid tropics. We have also been able to characterize species from the point of their compatibility for a mixed forestry programme by an appropriate mixture of light-demanders with shade-tolerants. Based on this principle it should also be possible to have a quick restoration strategy for desertified lands so that the normal process of forest development that takes a few hundred years could be condensed to a more reasonable but less than 100 years.

Philosophy of Development

Specially designed packages may have to be developed for a given cluster of villages considering micro-climatic conditions, socio- economic level and socio-cultural background of the people. The aspirations of the tribal man are unique because of his independent nature and his closeness with the environment in which he lives. His dependence upon nature is reflected in the undisturbed «sacred forest» he often maintained in the past, as part of the village system. The unique characteristics of the tribal man should be adequately protected during the planning process. The scientists, planners and administrators often have tried to impose from outside developmental plans that they consider are good for the people in the region without trying to understand the processes that operate in traditional ecological systems. The strategy for development should be one with which the local people can identify themselves. Such a philosophy in planning would take care of the traditional value systems and therefore would not only find ready acceptance by the tribal societies but would also ensure their participation in the developmental processes.

Ecological Process and Tropical Soil Fertility

Symposium presented at the IVth International Congress of Ecology, Syracuse, New York, August 11, 1986

Despite increasing conversion of tropical rain forest into crop and pasture land, production of food and export crops in developing tropical countries is not keeping pace with the need and demand. Most converted land is usable only for a few years, before it must be abandoned due to low crop productivity. Abandonment of non-productive land increases the pressure to cut down and convert even more of the remaining tropical rain forest.

This symposium, presented by ecologists and agronomists working in tropical ecosystems, began with the ecological reasons for agricultural problems in the tropics : the year-round hot wet climate results in high potential for nutrient losses and soil erosion. The challenge faced by scientists is to develop agricultural systems which are better suited to the environmental conditions of the tropics. A variety of approaches were suggested.

1. Choose high yielding crops with vigorous root systems; return crop residue to the soil, maintain a continuous plant canopy; promote efficient nutrient recycling.
2. Evaluate some of the ancient Mayan traditions, such as mixing nitrogen-fixing trees in with crop species.
3. Experiment with cultivation practices such as "conservation tillage" that are less disruptive to the soil.
4. Increase nitrogen-fixing plants in pastures, and use cultivations practices that make available the nitrogen reserves in the soil.
5. Increase reliance on naturally occurring organic fertilizers, and carefully match the type of organic matter added to the requirements of the crop plants.

Sustained yield agriculture may be possible in the tropics, but these and other techniques must be developed and utilized, if the goal is to be achieved.

IX th International Symposium on Tropical Ecology

The IX th International Symposium on Tropical Ecology will be held in Varanasi, India, on the campus of Banaras Hindu University from 11-16 December, 1987, with the co-sponsorship of the IUBS.

The overall theme is the « Ecological Management of Tropical Ecosystems ». Six sessions are planned on « Rehabilitation of Degraded Ecosystems : a Global Issue ». Two of these sessions will be devoted to concepts, strategies, formulation and implementation of environmental policy.

Four sessions each are expected to be devoted to : Air Quality, Plant Geography, Wildlife Conservation, Human Ecology and Mangrove Ecosystems. Several contributed paper sessions will also be held.

For information write to Professor R.S. Ambasht, International Society for Tropical Ecology, Department of Botany, Banaras Hindu University, Varanasi - 221005 India.

Symposium Workshop on Self-Organization Processes, Emerging Properties and Biological Complexity

April/May, 1988, Paris, France

Following the successful symposium on « Biological Complexity », organized within the framework of the 23rd General Assembly, 1985, the IUBS will organize a Symposium Workshop on the topic « Self-Organization Processes, Emerging Properties, and Biological Complexity », to take place in April/May 1988, in Paris, France. The meeting will provide the opportunity for a small interdisciplinary group of biologists, physicists, and information scientists to confront their views on the multiple facets of biological complexity.

During the last years, the possibility that systems consisting of interacting units may present new patterns of dynamical behavior transcending the individual subunit and characterized by coherence, cooperativity, and a rich space-time correlation spectrum has been intensely studied.

The purpose of the meeting would be to assess the analogies and differences presiding over the formation of such patterns in a number of representative examples ranging from molecular biology to ecosytems and including cognitive sciences; and to explore the constraints that structures at lower levels of organization represent for higher levels, as well as the manner in which selection at the organismic and population level alter the behavior of molecular and cellular processes. It is hoped that some promising tools for tackling these problems and some new direction of research will naturally emerge from this friendly confrontation.

At the medium term, the major purpose of the meeting will be to discuss the preparation of a book on the topic; and on the longer term, to discuss the establishment by the Union, of a scientific programme in the area of Biological Complexity.

Lecture/Training Course
Frontiers in Molecular Biology

Cairo, Egypt, December 5-17, 1987

An intensive Lecture-Course "Frontiers in Molecular Biology" will be organized in Cairo, Egypt; December 5-10, 1987, by the Federation of European Biochemical Societies (FEBS), the International Union of Biochemistry (IUB), and the Egyptian Biochemical Society; the venue will be the Siag Pyramids Hotel, Sakkara Road, Giza, Egypt.

The lecturers and the topics covered are as follows :

G. Bernardi (Genome organization and evolution);
G. Coupland (Transposable elements in plants);
F. Gros (Developmental neurobiology);
M. Grunberg-Manago (Translational control of prokaryotic gene expression);
G. Langley (Molecular biology of the malaria parasite);
U. Littauer (Expression of tubulin genes during brain development);
H. Saedler (Molecular genetics of plants);
D. Stehelin (Oncogenes);
W. Szybalski (New diagnostic probes);
I. Verma (Oncogenic viruses).

Another one-week Training-Workshop on "Biotin Labelling and Detection of Nucleic Acids", will follow in the period 12-17 December, 1987, at the National Resarch Council, Egypt. The workshop will be organized by the ICSU/Unesco International Biosciences Network, the Committee on Genetic Experimentation (COGENE) and the National Research Council (Egypt). It will consist of a practical and lecture course detailing the preparation and use of biotin-labelled polynucleotide probes, hybridization procedures (Southern, dot, colony, plague), under the guidance of members of the Laboratoire de Génétique Moléculaire, Institut Jacques Monod, Paris, France.

Attendance at these meeting will be limited for the Lecture Course to 50, and for the Training Workshop to 20 participants. A letter of application, together with a short curriculum vitae and a statement of interests and reasons for participating in the Course and or the Workshop, should be sent to both Dr. G. Bernardi : Laboratoire de Génétique Moléculaire, Institut Jacques Monod, 2 place Jussieu, 75005, Paris; and to Dr. M. Kamel : Nationnal Research Center-NRC, Tahrir Street, Dokki, Cairo, Egypt; before July 31.

There will be a US$ 250 registration fee for each of these two meetings (US$ 500 for both), which will cover accomodation and boarding. A number of *fellowships* are available for participants travelling and/or registration fees.

Financial Statement of IUBS for the Year 1986

Statement 1. Balance sheet at December 31, 1986 (Expressed in US dollars)

ASSETS		
Cash and Banks		
The Chase Manhattan Bank :		
Frankfurt/Main, in US $	190 667	
Paris, in US $	27 941	
Paris, in FF	4 714	
Paris, in US $ (Deposit account)	409 139	
		632 461
Other Assets		
Other receivables	3 524	
		3 524
		635 985
LESS : Liabilities		
Sundry creditors		54 133
Excess of assets over liabilities		
Represented by		
Accumulated Fund		581 852

The notes set out on pages 22-23 form an integral part of these accounts..

Statement 2. Income and expenditure for the year ended December 31, 1986 (Expressed in US dollars)

1. Income		
ICSU subventions	29 476	
Special Subventions from International Organizations (UNESCO, EEC, etc)	326 528	
Contributions from National Members	192 240	
Interests and dividends	29 129	
Gain or losses over exchange	− 1 088	
Other income	23 196	
		599 481
2. Expenditure		
A. Meetings		
Executive committee meetings	22 324	
Officers' meetings and travels	5 720	
Officers'		
	28 044	
B. Publications		**14 210**
C. Scientific Activities		
Grants to IUBS Scientific programmes	252 749	
Representation at scientific meetings	6 220	
Subventions to scientific meetings	12 940	
Contributions to other scientific organizations	6 119	
		278 028
D. Administrative Expenses		
Offices of the President and Secretary General	1 000	
Salaries	51 562	
Related charges	43 994	
General office expenses	27 500	
		124 056

Statement of income and expenditure for the year ended December 31, 1986 (continued)

E. Other

Bank charges	1 484	
Audit fees	3 880	
Others	131	
		5 495
Total expenditure		449 833
Total Income		599 481
Total Expenditure		449 833
Excess of income over expenditure		149 648
Accumulated balance brought forward		432 204
Accumulated balance carried forward		581 852

NOTES TO BE READ IN CONNECTION WITH THE FINANCIAL STATEMENTS

1. ACTIVITY

The activity of the Union is to promote the study of Biological Sciences by initiating and facilitating research and other scientific activities. The Union's income is derived from dues charged to member countries.

Income and expenditure not handled directly by IUBS but which relates to activities generated by the Union are not shown in these accounts.

2. CURRENCY

The financial statements are expressed in United States Dollars. Balances in other currencies have been translated into United States Dollars by applying the UNESCO standard rates of exchange, as at December 31, 1986.

The income and expenditure for the year were translated at the UNESCO standard rates applying at the date of payment.

The standard rates closely follow quoted market rates.

3. INCOME

Contributions have been recorded on a cash basis as in previous years. This is to say that only contributions actually received during the year have been taken as income. Therefore no account has been taken of contributions due but not received by December 31, 1986.

Income includes some UNESCO grants in order to finance certain scientific meetings to be held in 1987. The grants received during the year for these 1987 meetings are :

Object	US $	
Savanna programme	10 000	
Tropical Soil Biology and Fertility	10 000	
US MAB/UNESCO joint programme	85 000	
		105 000

4. EXPENDITURE

Expenditure is recorded on an accrual basis. This is to say that all expenses incurred during the year have been included in the accounts whether paid or not.

The apparent increase of administrative expenses in 1986 compared to 1985 can be explained by the fall of the exchange rate of the US Dollar to the French Franc.

5. FIXED ASSETS

Expenditure for the purchase of fixed assets is written off in the year in which incurred.

No expenditure is written off during 1986.

6. OTHER RECEIVABLES

The other receivables are :	US $
D.D.R. Dues for 1986	1 987
Interest on Chase Manhattan Bank account (Frankfurt/Main)	1 537
	3 524

7. LOANS

The Union in 1986 advanced loans in order to finance certain scientific activities to be held in the future. The loans made were :

Object	Loans not repaid in 85	Loans 1986	Refund 1986	Loans not repaid in 86
	US $	US $	US $	US $
5th International Congress on Culture Collection	5 000	—	—	5 000 Donation (in 87)
7th International Congress on Protozoology	5 000	—	5 000	5 000
Int.Congress on Devel & Comparative Immunology	2 500	—	2 500	—
Conf. on Plant Growth, Draught & Salinity	5 000	—	5 000	—
3rd Int. Conference on Aerobiology	5 606	—	—	5 606 (1987)
Conf. on Insect Diversity in the Tropics	2 500	—	2 500	—
10th Int. Congress for the Study of Social Insects	4 000	—	4 000	—
3rd Int. Congress on Paleobotany	—	3 500	—	3 500
11th Int. Congress on Plant Protection	—	5 000	—	5 000
Int. Congress of Mushroom Science	—	2 440	—	2 440
11th International colloque on Soil Zoology INDIA 1998	—	2 000	—	2 000
	29 606	12 940	19 000	23 546

The accounts when repaid will be added to income.

PUBLICATIONS REVIEW

BIOLOGICAL NOMENCLATURE TODAY

IUBS Monograph Series N° 2,

Edited by W.D.L. Ride and T. Younes
Published for ICSU Press by IRL Press, 1986 (70 pages).

The second volume of the IUBS Monograph Series is devoted to a review of the present state and current issues of biological nomenclature of animals, plants, bacteria and viruses. The papers included in this volume were presented and discussed at the symposia on «the Codes of Nomenclature»; organized within the framework of the 3rd Congress of Systematic and Evolutionary Biology (ICSEB-III), 1985, Brighton, UK.

DETERMINANTS OF TROPICAL SAVANNAS

IUBS Monograph Series N° 3.

Edited by B.H. Walker
Published for ICSU Press by IRL Press, 1987 (156 pages).

This volume, which is the third of the IUBS Monograph Series, brings together presentations made by savanna researchers at the workshop «Responses of Savannas to Stress and Disturbance», organized (Dec., 1985, Harare, Zimbabwe), by the IUBS in cooperation with the ICSU/Unesco International Biosciences Network. The authors were requested to produce accounts of the four major determinants-water, nutrients, fire and herbivory. The exclusion of Man as a determinant was deliberate, since the intention was first to obtain an understanding of the ways in which savannas respond to the combination of natural variation in these four determinants, and the added effects of Man.

INTEGRATED CONTROL OF CORYTHUCA CILIATA

West Palaearctic Regional Section Bulletin of the IUBS Section for Biological Control, 1986 (107 pages).

This Bulletin includes papers presented at two meetings devoted to the review the present state of integrated control research and activities of the lace bug, *Corytuca ciliata,* held in 1984, Zagreb, Yugoslavia; and in 1985, Padova, Italy. It also includes a series of recommendations for future research work, and a list of names and addresses of european scientists and institutes working in this field.

INTEGRATED CONTROL OF CEREAL PESTS

West Palaearctic Regional Section Bulletin of the IUBS Section for Biological Control, 1987 (242 pages).

The thirty papers included in this issue, were presented at the meeting held in Gembloux, Belgium, 10-12 February, 1986; they provide an account of the progress made by the IOBC Working Group on «Cereal Crops and Aphids Control». The meeting focused on three main directions : predatism, screening for resistant genes, and computing and use of forecasting models for aphids populations.

INTEGRATED CONTROL IN GLASSHOUSES

West Palaearctic Regional Section Bulletin of the IUBS Section for Biological Control, 1987 (202 pages).

This issue contains the papers discussed at the meeting of the IOBC Working Group «Integrated control in Glasshouses», held in Budapest, Hungary, from 25-30 April, 1987; and represents an account of the progress made since the last meeting in Darmstadt (1982), particularly regarding the application of *Encarsia formosa, Phytoseiulus persimilis* and three parasites of leafminers; and the use of *Bacillus thuringiensis* and *Amblyseius* spp. as control agents for Lepidoptera.

GUANACASTE NATIONAL PARK : TROPICAL ECOLOGICAL AND CULTURAL RESTORATION

by Daniel H. Janzen
Published by the National Parks Foundation and the State Open University, Costa Rica, 1986 (103 pages, 5 maps and 48 Photographs).

This book is a description of a project called «ecological restoration», which consists of a 70 000 Ha park to protect what remains of the dry forests that once covered 55 million Ha. in Mesoamerica. The area of the proposed park will include the present Santa Rosa National Park and all the land from it to the volcanoes.