POTENTIAL BIOTECHNOLOGICAL APPLICATIONS OF PACIFIC NORTHWEST FLORA

(Presented January 17, 1988)
by Brian L. Altonen

POTENTIAL BIOTECHNOLOGICAL APPLICATIONS OF PACIFIC NORTHWEST FLORA

(Presented January 17, 1988)
by Brian L. Altonen

INTRODUCTION

Biotechnology is a very new and growing applied science limited only by understanding and imagination. Due to biotechnology, we see nature in a new way; the roadsides, the beaches, the forests, and even our own back yards become untapped sources of research materials. Nature is no longer just a place to escape, but a place to go for intense scientific study. As we learn more about the innerworkings of the Earth, its geology, and plant and animal life, we will learn to solve many problems whose solutions were once unthinkable. So, it is the purpose of this presentation to acquaint you with the innerworkings of plant biotechnology and demonstrate that the Pacific Northwest is indeed a land rich in biomaterials and biotechnological potential, capable of influencing its own development as well as the development of the future of mankind.

In order to do we must consider these four questions:

1. How do we apply plants to the field of Biotechnology?
2. Why is the Pacific Northwest flora different from that of any other region of the United States?
3. Are there any new and undiscovered potentials, and if so how do we find them?
4. How would these new discoveries be of benefit to the Northwest in its socioeconomic growth?

Currently, a substantial percentage of our state's income comes from its botanical resources including: wood for lumber and paper; fruits for wine; and a variety of consummables. A smaller portion of this income comes from local sources of organically-grown herbs and spices, several wild-crafted medicinal plants, and a variety of edible wild mushrooms. When the impact of these botanical resources is viewed on a larger scale, for example in regard to the United States, it is found that we excel in only a select few areas of botanical resource production for which the Northwest is well-known, namely lumber, and select crops such as potatoes, sugar beets, mint, barley, and hops, edible fungi, fruits and wine.

The increasing need of a growing U.S. and world population must be met, and some of the Northwest's primary resources are now dwindling. One has to consider what effects the future could have upon our old-growth forests. The most obvious effect could come from timber harvesting, but let us consider a more hidden natural resource--the wild mushroom. With the increased popularity of edible wild mushrooms, it has yet to be seen what the effects of the related heavy foraging will have upon future mushroom availability and the future impacts upon their respective ecosystems. Recently, Springfield, Oregon's, Register Guard questioned the potential effects of heavy exportation, suggesting that we better control our harvesting in the National Forests. In order to better deal with the problems of supply and demand, mushroom culturing and indoor cultivation techniques are now being employed. As an example, Avocational Mycologist Mike Wells has developed his own personal collection of nearly one-hundred edible, or otherwise useful Oregon fungi. This living collection of mycelial growth networks stored in Petri dishes is perhaps the simplest example of how a better understanding of science can help to solve the problem of a limited supply and a respective high demand. Once we develop a better understanding of an organism's growth requirements, we can develop a technique for cultivating it with a greater degree of efficiency than nature alone usually provides. Viable germinating tissue can always be available to meet any unexpected rises in demand.

Other Oregonians are currently engaged in establishing seed banks of our native plants and important food plants which can be availed in the future for recultivating botanical resources lost through neglect, poor weather, disease, or poor cultivation and harvesting techniques.

An interesting example of supply and demand involves the increasingly popular Naturopathic Physicians (the N.D.'s). It is said that the N.D. is a symbol of the Northwest. With the only two accredited Naturopathic Medical schools in this half of the country (one in Portland, and the other in Seattle) more and more naturopaths are joining the workforce each year. The Naturopathic Physician usually relies upon several modes of treatment including: Homeopathy, Nutritional Therapy, Herbal Medicine, and Oriental Medicine; all of which employ edible and medicinal plants in their therapeutic regimes. This has most recently led to a rise in the demand for reliable, high-quality medicinal botanicals, and local farmers are responding to this need by organically growing important medicinal herbs such as Mint, Comfrey, and Nettles. A most recent success on behalf of the people at Portland's own National College of Naturopathic Medicine has been in the marketing of their own Nettles-derived allergy relief formula. This has brought about an increased demand for this plant. Similarly, with the increased interest in herb-related treatments nationwide, more and more herbs will be needed to produce the necessary products. Small local herb farms are limited in how much they can accomodate for this need. Facilitating the production of these and other medicinal botanicals will be one major application of biotechnology in the decades to come.

The naturopathic school has shown us that a herbal medicine does have the potential of reaching a larger market-- regional, and perhaps even nationwide. But the chance for this happening is usually very small. With few exceptions, these privately run businesses ultimately play a small part in the economic growth of the Pacific Northwest (examples of such include Herb Pharm & Rainbow Oils). In order to consider the greater economic potential of the Northwest we must recall those basic human needs which exist worldwide: food, shelter, energy, and medicine. If the Northwest can bring about a significant impact upon any one of these areas, then the resulting economic gain can far outweigh the sum of all other gains achieved so far.

THE APPLICATIONS OF BIOTECHNOLOGY

Considering 'Shelter', the value of the Northwest Timberlands, regionally and worldwide, need not be elaborated upon; except to mention the work of one local researcher, Dr. William Pengelly. In his labs at the Oregon Graduate Center in Beaverton, Oregon, Dr. Pengelly works with a newly discovered genetics researchers' tool-- the Agrobacterium tumefaciens. Agrobacterium tumefaciens is a bacteria which alters a plant cell's genetic make-up by infecting that cell and carrying with it foreign DNA which the host (plant) cells will recognize. One effect of the infectious process can be a cancellation of the inhibitory effect of hormones which the host plant naturally secretes. As a result, we see a 'burly' deformation developing in many of the Northwest's trees. These burls form because dividing cells are not being inhibited by the processes which would normally prevent their growth and division; just as an uninhibited cancer cell grows within the human body. Along with its own DNA, the _Agrobacterium_ _tumefaciens_ can carry any other genetic information that is linked to it. For example, the genetic information required to produce an enzyme, or a particular class of enzymes, involved with a unique metabolic process can be carried into the host cell. Then, if the infected cell has the necessary precursors for the enzymatic reaction, a chemical reaction can be made to occur following a recognition of the new genetic material. New breeds of _Agrobacterium_ _tumefaciens_ can be specially bred to fulfill a wide range of needs, depending upon the skill of the researcher, and a little bit of luck in breeding and selection of the appropriate bacteria and host cell lines.

Dr. Pengelly's work involves the use of _Agrobacterium_ in order to effect fiber production in the native trees of Oregon grown for pulp and paper production. But, there are many ways in which _Agrobacterium_ can be used; all with tremendous economic potential. Every plant cell line essentially becomes a miniature factory which can be applied to the production of medicinally and industrially useful substances. The two other major applications of plant material-- Food and Medicine --shall also involve extensive use of the _Agrobacterium_ in the years to come, once its applicabilities have been mastered by agrigenetic researchers.

A discussion of the Rape plant will help to bring about important information regarding the impact of plants and biotechnology on the Food Industry. For decades this member of the Mustard Family has given us an oil which is very useful industrially. It is typically not very edible though due to a bitter principle it contains called Erucic Acid. Recent Selective Breeding attempts by agronomists have resulted in a substantial reduction of the Erucic Acid levels found in

Rape seed oil. Not only did this make Rape seed oil palatable, Low-Erucic-Acid-Rapeseed Oil (known in the trade as LEAR Oil) has become one of the "healthiest" cooking oils ever to reach the supermarket shelf for it contains a high percentage of the desired monosaturated and polyunsaturated fatty acids, and very low levels of the less-desired cholesterols and saturated fatty acids. In fact it is far lower in cholesterol than any other cooking oil.

Rapeseed is already one of the twenty most important industrial crops in the world. Making it also important as a food crop would substantially improve its worth to a country where there is an economy dependent its export. The marketing of this new product, "Canola" Oil, exemplifies how much stereotypical ideas can play a role in what the consumer is made to believe regarding any new product. The advertising campaign shows a brilliant yellow field of what one would assume to be grain, yet in fact this is really a field of Rape plants in full bloom. Be it through Grafting, Hybridization and Cross-breeding, or through Genetic Engineering, the act of producing a new variety of food plant is not new. Only the techniques have changed as we become more precise in our ways and dig deeper into the phytogenetic code.

By domesticating many of our fruit-bearing plants, we have improved the quality of their fruits. Selective Breeding has allowed agronomists to produce thick-skinned oranges (for protection during shipping), larger apples, and rounder (more expensive) pears. We have produced plants that are more resistant to herbicides, pesticides, and the dreaded freezing temperatures. Yet, by selecting for a particular factor, we have negated generations of naturally-bred features that are more important than shape, size, color, and moisture content.

Such features include climate tolerance, and the multitude of natural pest resistancies. It is now the goal of a few agrigenetic researchers to bring back these natural resistances in rapidly propagating fruit plants such as Strawberry, Raspberry, Blackberry, Blueberry, and Currants. This would eliminate the need for excessive spraying of chemicals onto their growing areas.

THE HISTORY OF ECONOMIC BOTANY AND THE PACIFIC NORTHWEST

In consideration of the applications of plants to medicine, it is important to briefly reflect upon some related history. There was a time when what we now view to be the simplest and most basic of discoveries were actually landmarks in the developing understanding of normal and disease-related processes in the human body. One such discovery was made by Dr. James Lind in 1738, when he realized that a lack of citrus fruit in the diet of sailors in the British Navy was causing them to become ill. This discovery turned one of the most common disorders of that period, Scurvy, into one of the most treatable and preventable disorders of the Eighteenth Century.

Another epoch discovery was made by the Eighteenth Century physician William Withering who accepted as truth the testimonials made by seemingly untreatable patients who claimed that their illness was reversed by drinking an herbal tea made by an old Shropshire lady. When he investigated this woman's work, he concluded that the common garden and woodlands plant, Digitalis or Foxglove, was effective in treating their weak and failing hearts. Since Dr. Withering's discovery, millions of people in the United States have benefited from the Digitalis-related glycosides.

Later came the major discovery that the Mexican Yam contained an impressive amount of chemical compounds bearing a steroid skeleton-- a complex molecule made up of four interlocking rings which was practically induplicable in chemical laboratories. This discovery enabled pharmacologists to replace the old prescriptional steroid products, made from concentrated animal tissue, with a purer, less costly, and more reliable product. The assortment of new steroidal medicines we now have include: Cortisone, the Day-after Pill for rape victims, and the Birth Control Pill.

In the 1980s we discovered the anti-cancer, anti-leukemia, and anti-Hodgkin's Disease compounds found in American Mandrake, and the Madagascar Periwinkle. Each has given researchers a new chemical tool, and clinicians a new form of therapy. Very careful consideration is now being given to the potential anti-carcinogenic potentials of a native tree of the Pacific Northwest, the Yew Tree--The Tree of Immortality--an item of special interest which will be discussed later.

To some researchers the time has come to see if there are any strong anti-viral compounds capable of fighting the complex viruses such as the AIDS virus. Not too surprisingly, the highly complex Plant Kingdom does in fact produce these. Castanospermum australe, or the Black Bean of Australia, produces a toxin which selectively prevents certain viruses, including AIDS (HIV), from forming their protective outer coat. This toxin, Castanospermine, has potential for use in the treatment of AIDS patients. The U.S. native Water Hemlock (Conium maculatum) contains a similar compound (gamma-coneicine), which is not related to its famous and more deadly toxin--Coniine. Gamma-coniecine could theoretically be extracted, and/or efficiently synthesized in the plant cell following proper exposure to a specific Agrobacterium which inhibits Coniine production without altering the production of Gamma-Coneicine.

The history and ecology of the Northwest supports its enormous potential for making impacts on the field of Biotechnology. There is an extraordinary variety of plant-life due to its wide range of ecosystems: scrub plains, deserts, glaciated mountain peaks, volcanic pyroclastic flows, impenetrable rain forests, cultivated floodplains, estuaries, and marine tidal pools; all within the border of the State of Oregon.

Following its exploration by pioneers the Pacific Northwest soon became known as "the Garden of the West", growing and establishing its first major cities around the middle of the Nineteenth century. The City of Portland began as a pre-statehood settlement around 1850, and later became heavily urbanized, laying down its present roadways and concrete sidewalks at the turn of the century.

Concurrent with its exploration, the Northwest's flora was being catalogued by famous botanist-naturalists such as Asa Gray, Edward Greene, Thomas Howell, William C. Cusick, and William Suksdorf. Cusick and Suksdorf would become known as the noted taxonomists for cataloguing Northwest plants, and more famous botanists like Asa Gray, wrote about these findings. Much of the information on Northwest plants came from Trask River, Willamette River, and Pacific Railroad Survey specimens gathered by the Howell Brothers around 1883. Several decades would pass before special attention would be given to the uniqueness of Northwest ecosystems. The Northern California--Oregon surveys made by Engelmann and Parry in 1880 led them to conclude "Three Sisters would be the best locality to study the whole Oregon and Northern California forest range better than the known localities of Mount Hood." This led botanical explorers to suspect that nothing new was there to be found. The Northern United States, across into Canada and then to Alaska, would soon be explored, before the rest of the Pacific Northwest. The Northwest's unique ecosystems had yet to be discovered.

FACTS REGARDING ECONOMIC BOTANY

Unfortunately for the Northwest, Penicillen was discovered. For following the initial cataloguing of Northwest flora, the discovery of Penicillen changed the emphasis of natural products chemistry research, replacing the extraction experiments that were being done on native plants with synthesis experiments to be carried out solely within the chemists' laboratories. Furthermore, stress was placed upon the health care field by the two world wars. As wartime typically exerts a significant effect upon the growth of the medical field and its research efforts, this time these efforts were centered on the prevention and treatment of life-threatening infections following battlefield injury. New anti-microbial drugs came into being, not from the testing of newly discovered potentially medicinal plants, but instead through the chemical modification of previously known thereapeutic substances in hopes of obtaining a patentable, and perhaps a more effective drug. Due to the potential cost-benefits, more and more researchers were being drawn away from the outdoor environment and deep into the hearth of their petri dishes and testtubes. It was felt that the need for working long and hard hours, tediously extracting plant substances, and achieving less than predictable results from trial and error methods, would soon be over. The interest in medicinal plants had bottomed out.

As a result, many of the newly catalogued plants of the Pacific Northwest did not receive the same full attention and scrutiny by plant chemists that nearly all of the plants of the Eastern United States had received. This is most noticable when one tries to read about these plants. Most of the information regarding the medicinal value of the Northwest's plantlife is in the form of folklore handed down by the American Indians and early settlers. This contrasts greatly with the information found on Eastern North American flora which is not only a vast collection of folklore, but also contains information based upon the late 18th and early 19th century research being done on plant chemistry, toxicology, and pharmacognosy.

The Northwest's vast botanical resources have become lost and forgotten, and in spite of some obvious signs, these plants continue to be ignored in respect to their economic and medicinal potential. We have here plants with an incredible economic potential which have yet to be properly developed, or better yet discovered. Billions of dollars are being spent in a massive attempt to recover new and unusual drugs from the biologically-rich tropical rain forests. These tropical zones have already been plundered of their best flora, so attempts are now being made to reach southwards and across to other continents for new drug sources. A large portion of these efforts should now be re-directed into the biologically-rich regions of the Northwest; for example, into its rain forests. Our rain forests alone contain a considerable amount of biomass, with great variation in its metabolic processes. There must certainly be new plant species yet to be discovered with their own unique chemistries and therapeutic potentials.

Recently, estimates have been made that approximately one out of every 125 fully researched plants has economic potential as a medicinal, and that one out of every four prescriptional products is botanically-derived. These estimates have been made based upon the limited number of plants currently used in prescriptional drugs and do not account for the other 60 or more "non-pharmacological" plants which are used in the manufacturing of nearly all prescriptionals, (for example, gums, gels, resins, etc.) Nor does it consider the vast assortment of "nutritional" herbs for which there is at least a $250M annual market. Approximately 400 species of plants are now being sold as nutritional supplements, which are obviously bought for self-medicating purposes. Most of the plants which have undergone laboratory testing been tested for one sole purpose--for their cancer fighting properties. One can only guess how useful these plants might be in fighting other diseases of the human body, for example, Epilepsy, AIDS, Herpes, Sickle Cell, and the variety of Blood Coagulation Disorders.

An estimated $40B is being spent annually on drugs in this country right now and considering that roughly one-fourth of all prescriptional medicines is plant-related, the estimated value of our forty prominent plant-derived medicinals is $10B. Divided amongst the 40 plants, this makes each plant worth at least 250 Million dollars to the manufacturer. These figures were proposed several years ago by one who is perhaps the world's foremost expert on Economic Botany Norman Farnsworth. Due to certain factors missing in his calculations, the actual worth of any plant-derived medicinal substance can actually be found to be around $465M. Unofficial estimates are that a substance has to be worth $500M to $2B dollars in order for a drug company to consider testing, producing, and then marketing it on a large nationwide scale. Many of these substances in pure crystalline powder form cost $1000 to over $10,000 per ounce dry weight to make and/or purchase. Only a few granules may be all that is necessary to produce a therapeutic response in an individual. To the representative drug company it is important that each newly marketed substance be able to capture a considerable part of the massive prescriptional sales market, which is estimated to be over 2 Billion Rx's, with average costs ranging at $12-15 each, to $20-40 each for some of the more common "exotic" Prescriptions. The cost for a chemotherapeutic substance can go beyond the thousand dollar mark per day!

Many of the drugs we see coming out under the current system of research and development are "Exotic". They are typically used to treat afflictions such as hormone imbalances, cancer, leukemia, Hodgkin's Disease, high blood pressure, and certain heart afflictions. One major role of biotechnology might be to reduce the cost of their production and increase their availability through specially designed programs in clonal propagation, genetic alteration, and plant tissue culturing. It is important that all of these procedures be understood because they will be used extensively to solve many of the problems of the 21st Century regarding starvation, malnourishment, poor health and disease, and the restoration of limited botanical resources.

Biotechnology offers us a better chance for dealing with our botanical resources in a controlled manner. It provides us with the means to better utilize them for economic gain for the entire Pacific Northwest. Ther following are some examples of local flora and descriptions of how this might be done.

THE TIDAL POOLS

Tidal pools are usually an indicator that a tremendous amount of speciation and specialization is occurring. Each tidal pool is a miniature ecosystem whose level of biomass and energy conversion rates reach incredible proportions. The energy of the sun and the ocean are continually being absorbed and converted into a form which can be better utilized by the local fauna and flora. One effect of this is the rapid conversion of energy into the production of biomaterials, which typically becomes segregated into visible layers called growth zones. Zonal gradation, or stratification, of the Northwest's shores can best be seen in its tidal pools. The different types of barnacles grow best at different levels, which are different from the levels at which the starfish, sea anemones, and sea urchins grow. The different forms and colors of Algae plants also display these growing habits. Each chooses the depth to which it is best adapted, according to shape, strength, turbulence from wave action, color pigmentation, and the reduction of sunlight due to water turbidity.

Algae such as Kelp have provided the Orientals with food for thousands of years, but only recently have we begun to take a serious look at its nutritive potentials. Saltwater algae has given us useful gels which serve as thickeners and stabilizers in many of the foods we eat. One particular example is the Red Algae Chondrus crispus, or Irish Moss. It is utilized extensively for its Carageenan in the manufacturing of cheese-cakes and ice creams.

Dulse and Laver are used in the preparation of soups. The Kelp, a form of Brown Algae, doesn't give us any overly useful food substances, (aside from the nutritional supplement tablets people often take) but it can be used for the production of other biomaterials such as ethanol for fuel. Chlorella, a form of green algae, is now being sold for its highly nutritious qualities. Estimates have been made that we can grow as much as forty tons of Chlorella in the same area required to grow one ton of Soybean, or serve as grazing land for 250 pounds of beef!

A low cost means for the production of these algae now exists involving the use of aquaculture methods. Theoretically, on the shores of the Pacific Ocean we could develop growing beds or isolated pools in estuarine areas, causing little or no environmental effect upon the shorelines' appearances and ecology, and making better use of this continuously active energy source.

THE ESTUARIES

One negative environmental effect of our vast logging operations in the Northwest is the production of waste materials in the form of driftwood, bark chips, sawdust, and processed pulp remains. Much of this material is thoughtlessly dumped into the estuarine environment thereby ruining the ecology of this ecosystem. Estuaries are necessary to many different forms of wildlife existing along our shorelines: from algae and shellfish, to sea mammals, fish and birds. When there is an excess of woody particles along its shorelines, the slow decay of wood debris in the estuarian environment it drastically alters the natural chemistry of this area. Chemically treated wood pulp creates even more havoc in the delicate balance nature has provided.

The natural decaying process of wood has been studied by Dr. Gold of the Oregon Graduate Center. His work has shown that one particular wood decay fungus (Phaenerochaete chrysosplenium)--the White Rot fungus seen on some cut logs--is important to the degradation of sturdy wood fiber, lignin, to its smaller chemical components. By degrading lignin the remaining inner portions of the woody materials are exposed to the environment for further decomposition to occur. Now, because of a special technique in genetic engineering known as Protoplast Fusion, unique forms of this fungus are being produced which have promising effects on the delignification of decaying wood debris. In theory, the careful manipulation of this fungus could result in a more efficient fungal decaying system, useful for chemically degrading wood debris so that it can be utilized economically for fuel, chemical and paper production, rather than be simply disposed of into the environment.

MARSHES, FIELDS, AND WOODLANDS

Travelling inland we come upon the grassy and marsh-like areas where Western False Hellebore (Veratrum californicum) grows. Western False Hellebore has been of major interest to livestock growers and toxicologists due to its effect on grazing cattle and sheep. The most obvious toxicological effect is to cause a fetal-embryo malformation, often referred to as the Congenital Monkey-faced Syndrome. Newborns will have severe limb deformity and a displacement of key facial features, including fusion of the eyes, following their exposure to Veratrum's toxins during development in the womb. Due to the overwhelming number of known and unknown toxins in Veratrum, little could be done to isolate the toxin(s) directly responsible for this effect. With today's increased chemical-technological capabilities we are now able to isolate them. Toxins of such a selective nature can make excellent research tools in the search for more answers. Their effect on embryogenesis implies that cell division is being effected, and considering the number of different toxins in this plant, another potential chemotherapeutic drug might exist within this plant's tissues.

Travelling inland Cascara Sagrada (Rhamnus purshiana) can be found. Cascara's fame is extensive with its primary use being as a laxative during the 19th Century. Cascara owes its strong laxative properties to some rather complex chemical compounds best found in its roots. Buyers for Cascara roots live along the roadsides between Western Washington and Oregon. The freshly-bought roots are allowed to age for a few years and then re-sold to natural products chemists who'll extract the bitter Cascara resin.

Resins are usually large, rather complex molecules and making them is quite difficult to do in the chemistry laboratory. But with careful research we should one day be able to culture cells from a plant such as Cascara in order to use the culture to produce this medicine in larger amounts than what might otherwise be found in nature. By carefully selecting those plant cells which are producing the resins in large amounts, or by genetically engineering the Cascara cells to produce resin in greater than normal concentrations, ample resin could be produced, extracted, and then sold for use as a medicine; or perhaps for the purpose of modifying it into another more useful chemical compound. The need for aging the roots in a root cellar might no longer be necessary.

Recall what has been said about the Agrobacterium tumefaciens. It can be used to interrupt the normal inhibitory action which exists in a growing plant cell causing large amounts of plant material to grow from which an extraction can be done. The genetic material introduced by Agrobacterium can carry with it a nucleic acid sequence capable of turning on genes which produce the enzymes for a particular metabolic pathway. A new enzyme could be added to the normal metabolic sequence thereby producing a new and different metabolic end product not yet found in that plant cell, or in nature for that matter.

The Oregon Grape and Barberry shrubs of our forest floors contain chemical substances which have served as diuretics and urinary tract antiseptics. Techniques similar to those mentioned above for Cascara can be employed here as well. In fact these methods are theoretically employable to almost any culturable plant tissue. The Pacific Northwest offers Devil's Club and members of the Valerian Family as opportunities to utilize such a program.

A particularly interesting example of the application of Agrobacterium involves our native Valerian. Valerian is best known for its sleep-inducing effect whereby it reduces the pre-sleep stages one normally experiences in bed. It has tremendous potential for use in certain types of insomnia. Due to the recently proven effectiveness of Valerian root's medicinal activity, it now serves as an example of a plant with economic potential. The suspected group of medicinal compounds has been given the classification of Valepotriates. Valepotriates are found in fairly low concentrations in the Valerian root and are present in even lower concentrations in the American plant. Plant Tissue Culturing, by genetically engineering the Valerian root cells to produce a much greater concentration of Valepotriates, might enable us to produce a greater supply of the Valepotriates with which to do more biochemical, physiological and clinical research. The Culturing of plant cells in Valerian root has been tried, and Valepotriate production has been altered through biotechnological means.

The Vanilla Leaf (Achlys triphylla) offers us another such research opportunity, as well as the Wild Ginger (Asarum caudatum). Vanilla Leaf is a source for coumarins; and Wild Ginger provides us with a viable alternative for the aromatic oils of Ginger (Zingiber sp.). These plants produce their aromatic substances in differing concentrations depending upon various environmental and growth factors. So an understanding of the factors which effect aromatic oil production in its rhizome cells must be better understood before the controlled synthesis of the Ginger fragrance can be obtained.

THE TEMPERATE RAINFORESTS

We have yet to adequately research the economic potentials of the Northwest's Rain Forests, especially in regards to medicine. The Rain Forest environment is extraordinary in that miniature ecosystems can be found within the millions of pockets and crevasses of its trees and forest floor. Every mini-ecosystem, or microsystem, has the potential of producing one or more new genetic variations of plants should the factors required for genetic selection, competition and evolution be present. There is probably a considerable number of uncatalogued species on the verge of extinction at this moment in our Rain Forests. We have just begun paying closer attention to the previously ignored inhabitants of the forest floor such as Lichens, Hornworts, and Liverworts. Potential medicinal compounds have recently been found in this obscure group of flora. New and unusual orchids have recently been discovered. These and other plants with unusual chemistries are waiting to be found, before they are lost forever through extinction.

In order to preserve these plants clonal propagation should be used. By hormonally stimulating the regeneration of an entire plant from a crudely grown aggregate of cultured cells, florists have been able to bring unusual exotic flowers such as the orchids to the common everyday marketplace of our city sidewalks and floral shops. Clonal propagation will probably be widely employed in the production of not only decoratives, but also in the production of food-, drug-, and industrially-useful plants by the turn of the century. It is an effective way of making sure that plants which meet a particular requirement are cultivated. The most nutritious, the most medicinal, and the most economical plants can be selected for.

The Evergreen Forests offer us a potential for harvesting polyterpenes. The Polyterpenes is a very large group of vastly differing chemical compounds with just as many different uses. One potential used projected for the future is their use in the production of combustible fuels. To date, the extraction process has been a very messy one. The American Indians boiled pine bark in order to extract its tars which were used in making their birch bark canoes. Not too much has changed since then. Pine bark still must be boiled in very large amounts in order to produce a workable amount of pine tar, thereby making the extraction process unfeasible for a variety of reasons.

Greater economic potential for the Northwest's Evergreen Forests involves Yew trees. Yew trees grow scattered amongst the Douglas Fir trees being harvested for their lumber. They are customarily discarded and burnt in slash piles. Research on the Yew Tree shows that it has a potentially chemotherapeutic chemical compound --Taxol-- which has only recently been given its due attention. Research on Taxol has proceeded along very slowly for more than a decade. As a plant-derived cancer-fighting compound it has tremendous economic potential, which has led to the recent increase in attention being paid to it by many Natural Product Chemists.

There are occasional groves in the woodlands where Yew Trees dominate and attempts are being made to protect these areas from any future zealous over-harvesting or senseless debarking of standing trees. Being that these trees grow to over a thousand years of age, it would take well over a century to replace a grove of harvested trees. Several decades are required for a single young tree to produce enough bark for harvesting purposes.

Several tons of tree bark are required for the extraction of only one-half cupful of Taxol. Yet, this would only be enough Taxol to treat several people for ten years; or enough to supply a couple of hundred people with just their initial chemotherapy dose. It has been said that in all of the existing Yew trees there is only enough Taxol to provide treatment for just a few thousand cancer-ridden people.

In spite of these sombering facts, the indigenous nature of the Yew tree gives it exceptional qualities which, when considered along with other research potentials, favor its being experimented with locally. The Yew tree has adapted to the forces of natural selection in this area and is relatively widespread making it more available for research than the Madagascar Periwinkle and the Adirondackan Mayapple. This would facilitate attempts at clonally propagating the plant from cuttings or plant tissue cultures for the expressed purpose of utilizing the biological material for the extraction of Taxol. The same can be true if the plant is modified in its growth rate and/or its production rate of Taxol with genetic engineering.

Other potentially chemotherapeutic plants are now being studied as well, but very few are native to the United States, and many produce their compounds in even lower concentrations than the Yew Tree. Other Gymnosperms being studied for their chemotherapeutic potential include: Red Cedar (Juniperus virginiana = podophyllotoxin), Incense Cedar (Libocedrus decurrens = deoxypodophyllotoxin), and Bald Cypress (Taxodium distichum = taxodione & taxodone). Members of the Hepaticae (the Liverworts) and the Lichenae (the Lichens) are also being tested for the effectiveness of their noted chemotherapeutic potentials. Generally speaking, plant-derived chemotherapeutic compounds come from plants which are deadly in trace amounts including: Castor Bean, Precatory Bean, and European Mistletoe. But extreme toxicity is not an essential requirement for chemotherapeutic potential as exhibited by the tannins in Oriental Green Tea, and extracts taken from our local Arctostaphylos and Alder trees (Alnus oregona). Tremendous opportunities still exist throughout the Plant Kingdom in this area of research.

Finally, the Northwest Rainforests provide us with potential sources for suspected medicinal compounds such as flavonoids, sesquiterpenes, and triterpenoids, and potential sources for food additives in the future such as nutrients, acidulants, thickeners, colorants, flavorants, and odiferants. Innumerable applications to the perfume and cosmetic industries, and the high-tech chemical industries, exist as well.

THE RANGE AND DESERT REGIONS

For a final look at Northwest ecosystems, one must turn to the deserts. The future potentials for Oregon's deserts are the least explored of all. We must consider the potential use of this land in the decades to come. The production and testing of artificial biomes might be one research route that can be taken. Artificial biomes are essentially glass-enclosed habits. Growing crops under glass allows for better conservation of heat and water, and better control of important environmental factors such as sunlight, temperature, humidity and soil condition. The goal is to make better use of a previously incultivable area.

Certain trees have been found to grow well under desert conditions and are capable of producing shade in only a few years, for example Leucaena. In order to conserve water, careful irrigation techniques, such as drip irrigation, are now being employed and could become economically feasible within a few years. With drip irrigation, the water is continuously dripped onto the exposed root system of a plant growing in suspension. Another approach is to use trough irrigation methods, growing the plants in a steady flowing stream of nutrified water. This requires more water and considerable more care than the drip irrigation method since a much larger water pump is required. Applications of solar panels could provide electricity for the pumps, and other machinery involved. The plants would grown in a sterilized medium, preferably perlite, vermiculite, or "stone-moss", a unique fibrous and sponge-like rock material similãr in chemical composition to pumice.

By carefully controlling the environment in an artificial biome it could be made inhabitable, and then given different climactic regions ranging from arctic and temperate, to a tropical rain forest; thereby enabling one to grow an impressive variety of fauna and flora. Such experimental undertakings are right now in the makings. The Monsanto Corporation has already succeeded in growing a number of our edible plants in drip and trough irrigation systems, and are right now in the process of setting up an artificial biome in the Texan desert plains Biomes such as these will provide the means for scientists and other workers to live in dry abandoned and previously uninhabitable regions such as those found elsewhere on Earth, on the Moon, or on Mars.

CONCLUSION

In conclusion, as the research into biotechnology continues we will begin to better visualize ways in which we can live with and incorporate all that is around us into our daily lives. Advances are occurring right at this moment which shall influence our food, medicine, and energy sources, and even the some of the least suspecting of things such as shelter, clothing, cosmetics and perfumes. Very few Americans will remain uneffected by this. When we consider the needs of our expanding population the usefulness of biotechnology becomes clear. As research into its applications continues, it will be up to everyone to stay informed of the changes which are occurring.