

Medicinal Plant Research and Utilization: Trends and Opportunities



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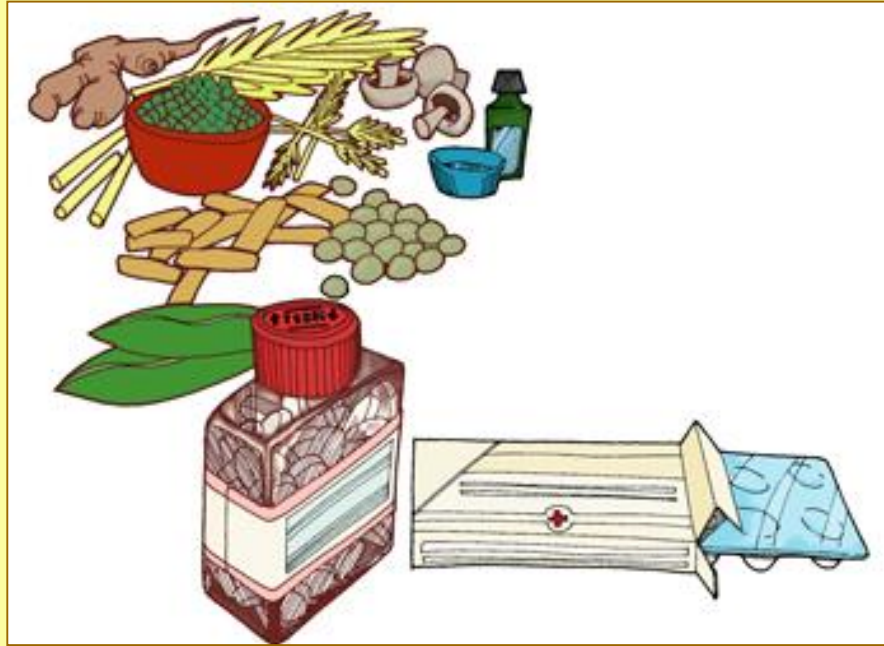
Natural environment has been a source of medicinal agents for thousands of years, since healing with plants dates back probably to the evolution of *Homo sapiens*.



Main centers of healing with MAPs

(Traditional Medicine)

- **African** traditional medicine
- **American** traditional medicine (North, Central and South)
- **Australian and Southeast Asian** medicine
- **Ayurvedic** medicine
(Indian Traditional Medicine)
- **Chinese** traditional medicine
- **European** medicine
- **Classical Arabic and North African** traditional medicine
(The Middle East is known as the cradle of civilisation and many plants grown nowadays have been domesticated in this region)



**According to an WHO estimate
80 % of the world's population relies
chiefly on traditional medicine, a major
part of which involves the use of plant
extracts or their active ingredients**

(Akerele, 1992)

The role of MAPs Today

For many, plant medicines are a necessity, since



costly pharmaceutical drugs are unaffordable

For others, plant medicines are a healthy alternative to synthetic medicines



to avoid their harmful health effects.

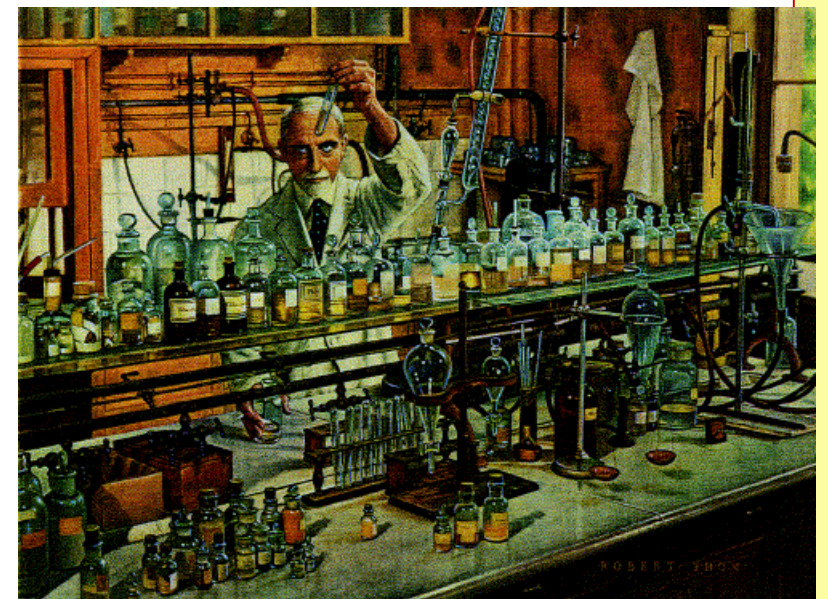
Plant families containing over 100 species with therapeutic value

Family	Genera	Species
I. Monocots		
Liliaceae	45	165
Orchideaceae	45	135
II. Dicots		
Compositae	89	331
Fabaceae	91	313
Ranunculaceae	31	208
Lamiaceae	46	189
Rosaceae	28	146
Apiaceae	34	123
Rubiaceae	35	118
Euphorbiaceae	30	104
Asclepiadaceae	29	101



Most natural products have yet to be investigated

- Only **ca. 200,000** the naturally occurring secondary metabolites **isolated and identified**
- **Chemical compositions** are of an enormous structural variety
- **Synthesis pathways** within plants are often complex and branched
- **Role** of many secondary plant principles in organisms **is still unclear**



Wild-crafting = Exploiting Natural Biodiversity

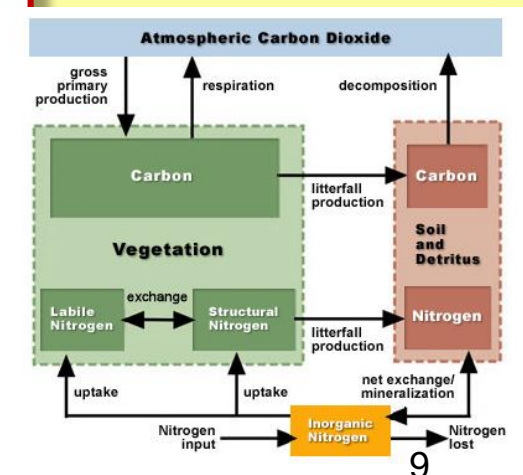
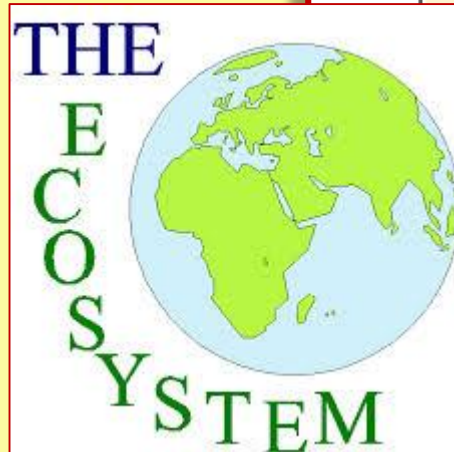
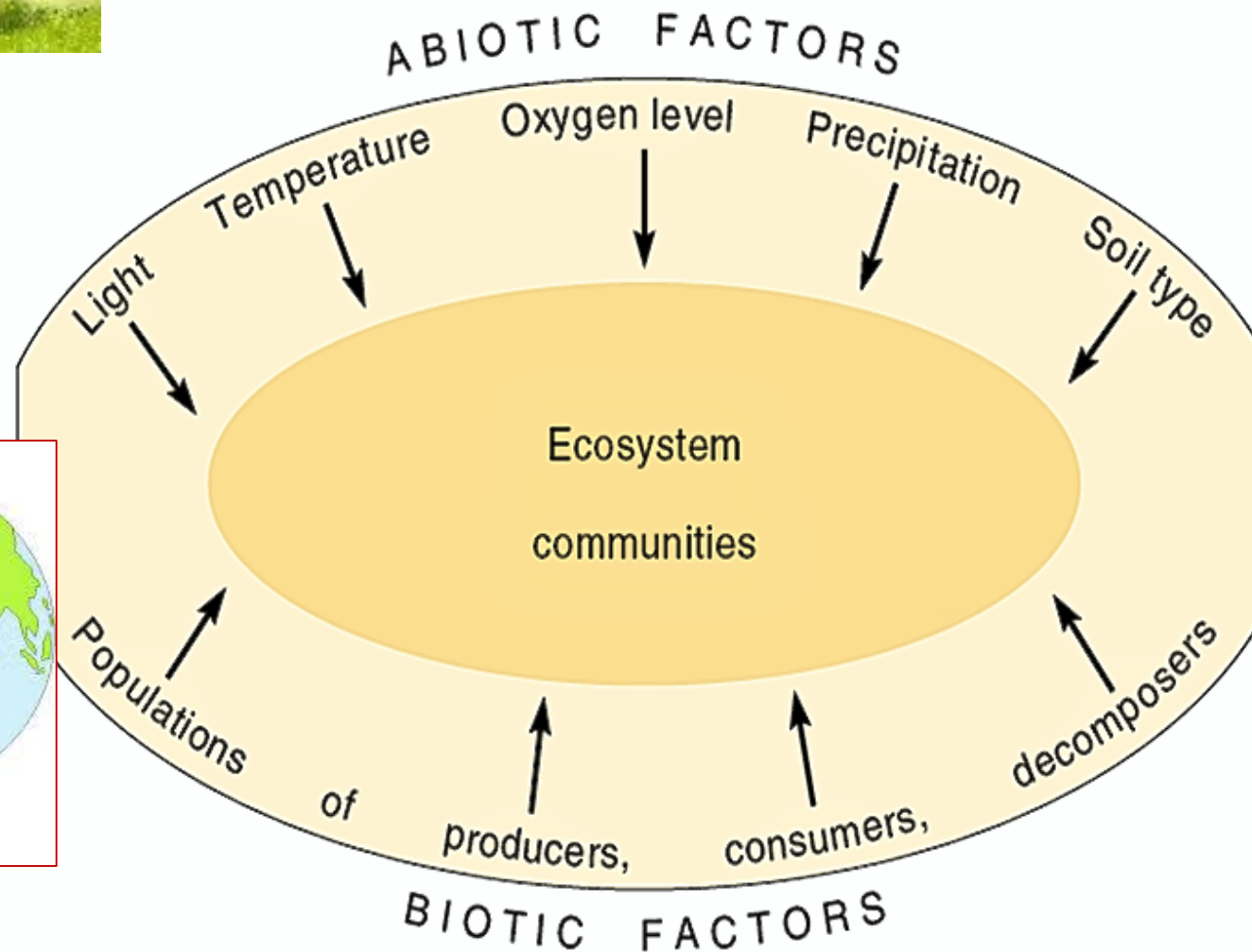
**Wild Collection of Plants:
very „natural“ – including Diversity**



Plants, as members of the ecosystem



Regulating factors of the Ecosystem



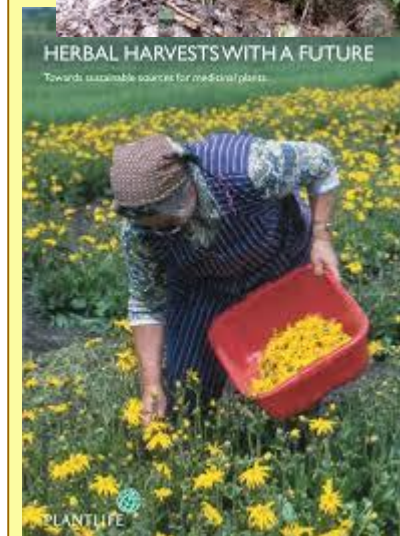
Terrestrial Ecosystem Model (TEM)
The Ecosystems Center, Marine Biological Laboratory (Woods Hole, Massachusetts)

Undesirable features of the over-exploitation



The over-exploitation of natural biological resources of MAPs is frequently:

- **destructive,**
- **indiscriminate** and
- **inappropriate harvesting practice/techniques**
- ultimately lead to the **imminent extinction** of many species.



THE CHIANG MAI DECLARATION (1988)

SAVE THE PLANTS
THAT
SAVE LIVES



*WE, THE HEALTH PROFESSIONALS AND THE PLANT
CONSERVATION SPECIALISTS, have come together for the first
time at the*

*WHO/TUCN/WWE International Consultation on Conservation of
Medicinal Plants, held in Chiang Mai, 21-26 March 1988.*

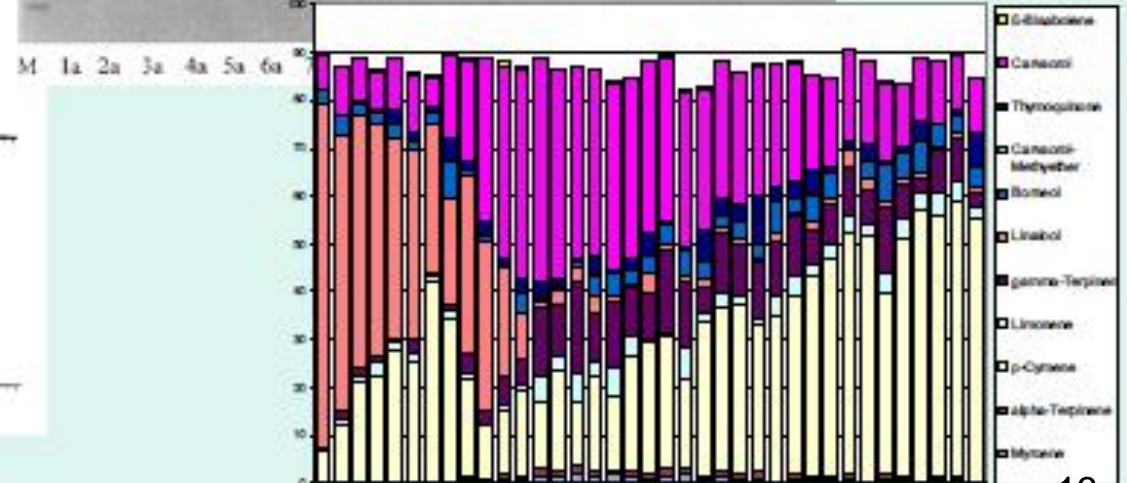
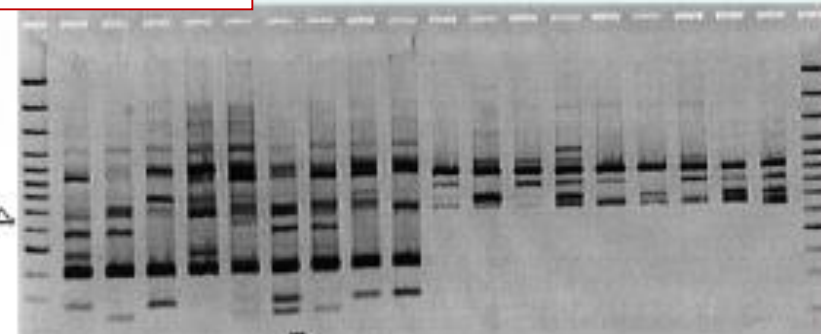
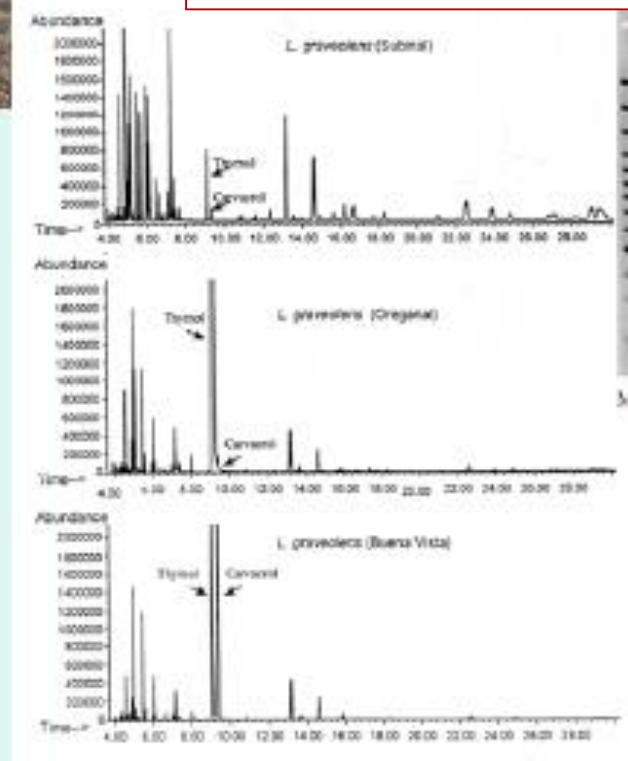
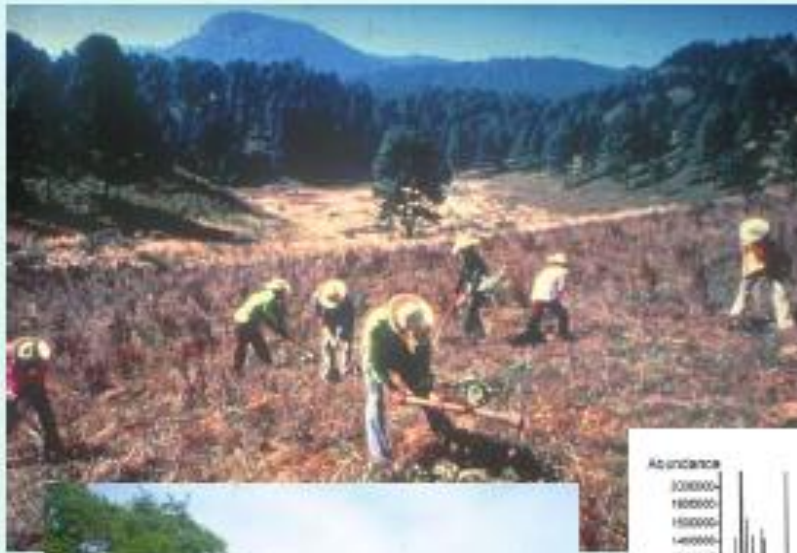
Possible solutions to save endangered MAPs

- **Sustainable use** of the natural resources of Medicinal and Aromatic Plants,
- **Domestication** / Introduction into cultivation of endangered species.

Cultivation of MAPs:

High number of species / rich biodiversity,
Small acreage → 'specialist minor crops'

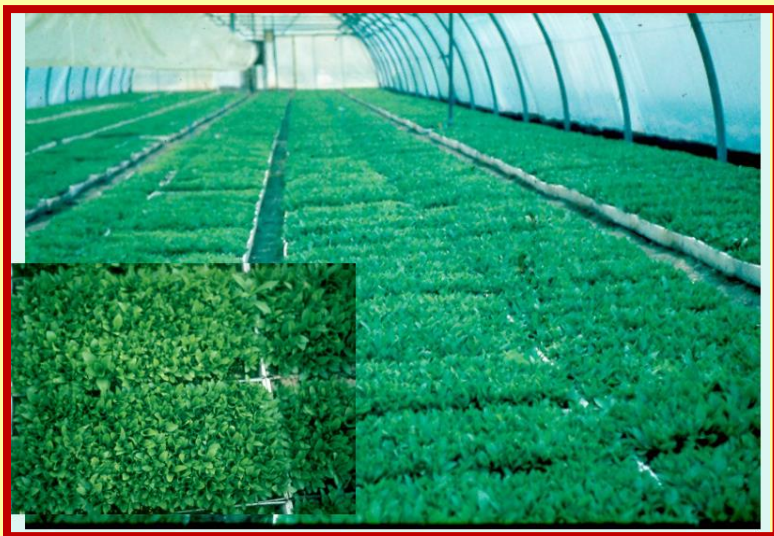
Dualism:
Cultivation
hand in hand with
Selection and
Seed Production



Medicinal and Aromatic Plant „factories” of the present

(Photos: courtesy Franz, 2011)

Gentiana lutea production in Bavaria



**Plantlet
production**

**Field
production**



**Production in
mountain fields**



Industrial uses of MAPs

Phyto- Pharmaceuticals

Galenicals

Intermediates
for drug manufacturing

Health
Foods

Animal feed
additives

Herbal teas

Industrial/
pharmaceutical
auxiliary
products

Traditional medicines

New drugs



What do we need to know about MAPs ?

to make them produce the desired active principles in sufficient

- **quantities**
- **quality**
- **safety**
- **efficacy**



BASELINE → MAPs are most diverse and versatile

Several sciences involved in the study of their:

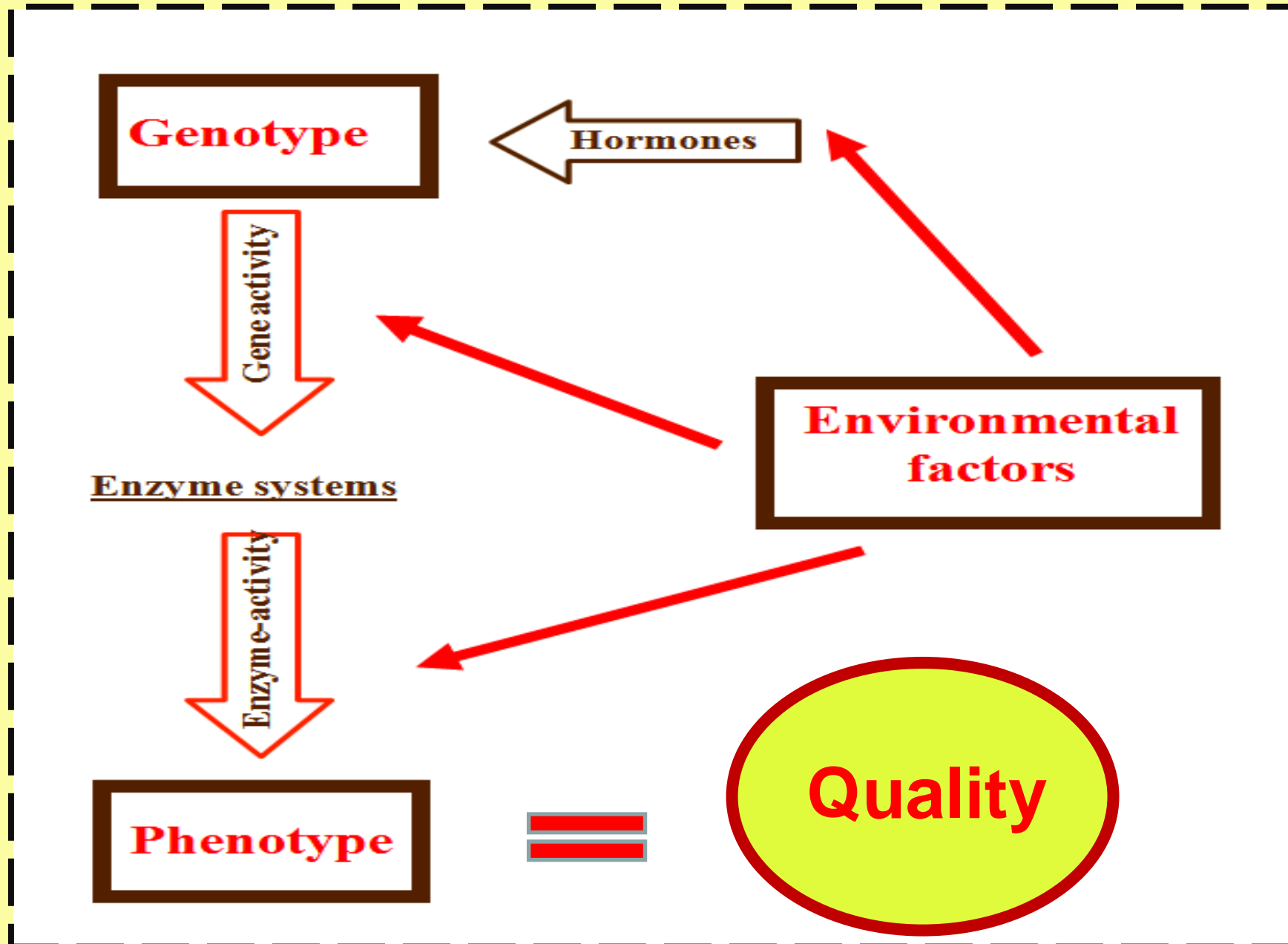
- botanical
- ecological / physiological
- chemical properties and
- economic (health/medicine/feed additive) importance

and as a consequence

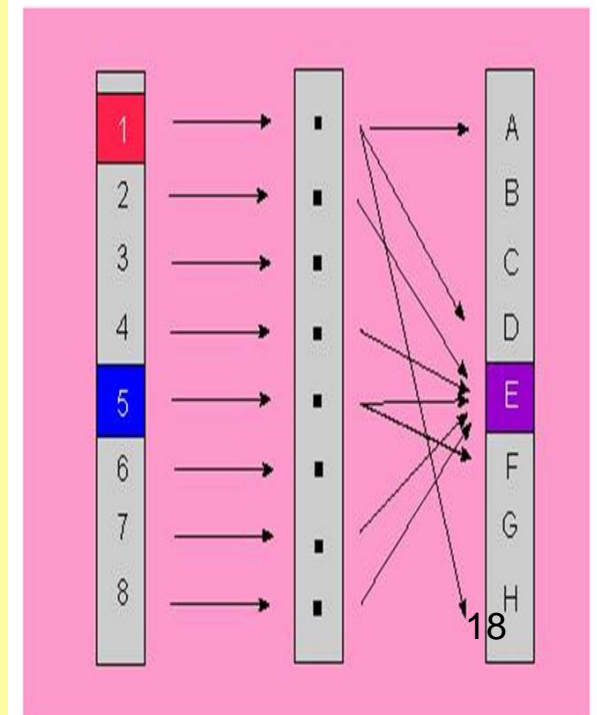


multiple forms of utilization

Basic Factors influencing plant growth and development



One gene theory



Phenotypic Diversity in Basil (*Ocimum* spp.)

Phenotypic Diversity in Basil (*Ocimum* spp.)



Metabolic engineering

Preconditions for metabolic engineering:



- = identify the details involved in the biosynthesis of a natural product,
 - = at **enzyme level** and
 - = at **regulation** level,
- The general concept of metabolic engineering is that
 - = certain **pathways** within a biosynthesis network could be **stimulated / favored over others**, by over-expressing a crucial enzyme
- (e.g.: **squalene synthase gene** → higher biosynthesis of triterpenes and phytosterols in *Panax ginseng*)

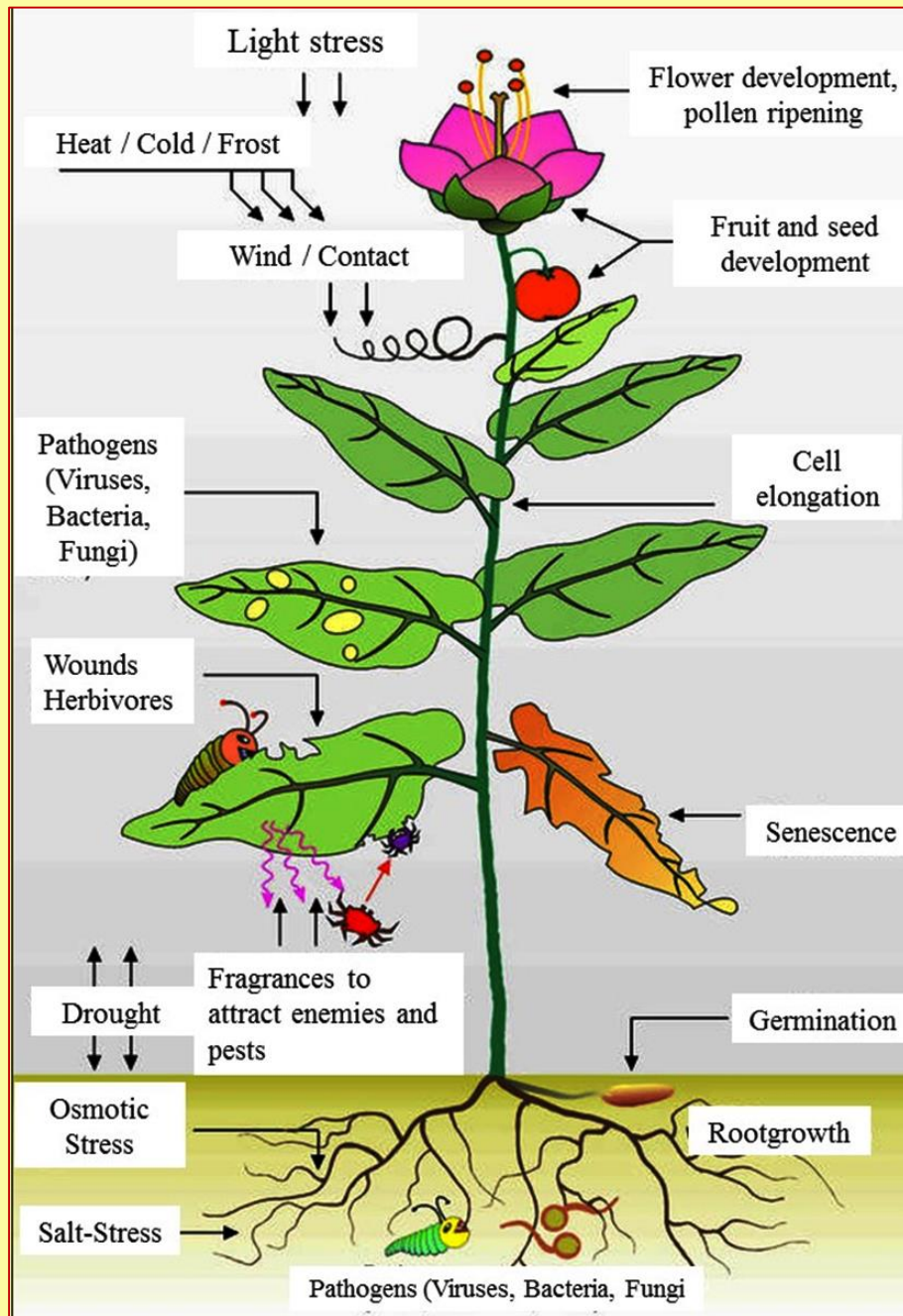
Silent metabolism in plants

“Silent” Metabolism

- **geranial and neral**
 - Geraniol dehydrogenase
- **citronellol, citronellal**
 - Geraniol reductase
- **geranyl acetate, citronellyl acetate**
 - Geraniol / citronellol acetyltransferase
- All present in tomato fruit cell-free extracts
- Silent Metabolism (Lewinsohn & Gijzen 2009)



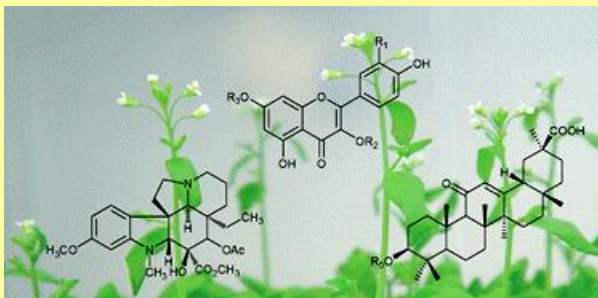
Adaptation to adverse conditions (Importance of Secondary Metabolites)





and to Stress



- ➡ **Metabolites** = end-products of cellular regulatory processes, and their levels can be regarded as the **ultimate response of biological systems** to genetic or environmental changes
- ➡ The set of metabolites synthesized by a biological system constitute its „**Metabolome**”




Springer Link  

January 2002, Volume 48, Issue 1-2, pp 155-171

Metabolomics – the link between genotypes and phenotypes

Oliver Fiehn



PLANT MOLECULAR BIOLOGY

Look Inside

Springer Triple targeting of DPP homeostasis

Special features of MAPs

Selection and Breeding

- Due to the high costs of chemical analyses, the **breeding of MAPs can be rather costly**
- The effect of influencing factors must be investigated **in the course of breeding**

As a result:

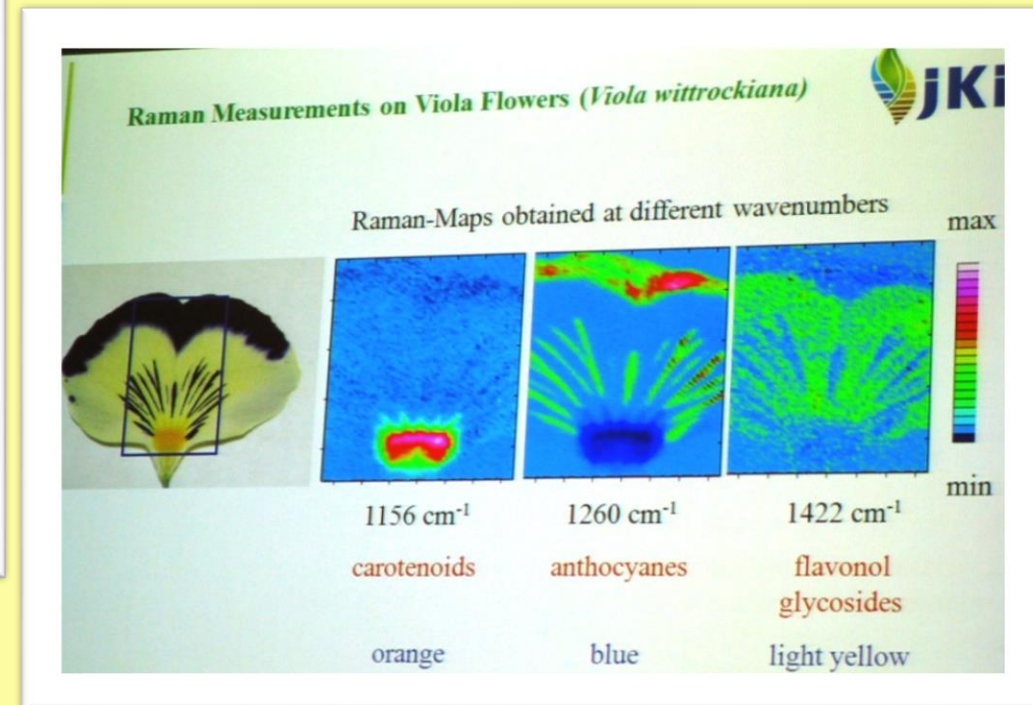
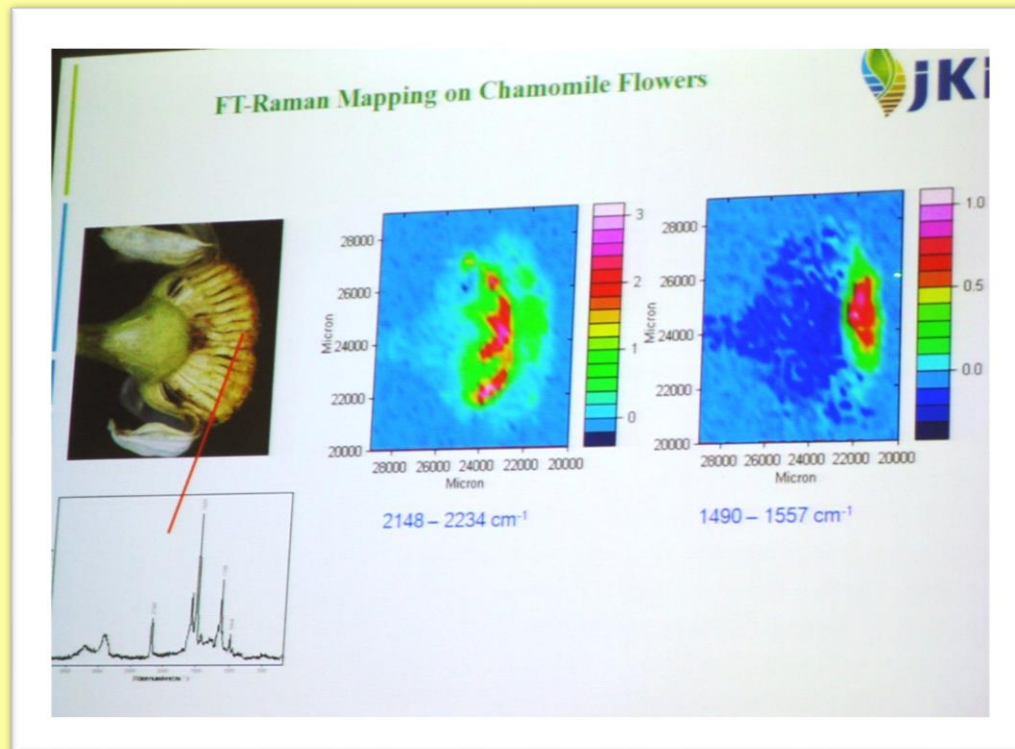
**New analytical methods have
been elaborated**

*with the advantage, that these can be used in the
subsequent chains of quality assurance*

Cutting edge analytical techniques used with Medicinal and Aromatic Plants

- **Chromatographic separation methods**
High throughput screening (HTS)
- **Fast chromatographic methods linked to modern sample preparation techniques**
- **Rapid High-Throughput Methods (RHP), like**
Vibrational spectroscopy
 - **MIR** = Mid Infrared Spectroscopy,
 - **NIR** = Near Infrared Spectroscopy and
 - **Raman** spectroscopy,
 - etc.

FT-Raman Mapping on Chamomile and Viola-flowers



Courtesy: Schulze, M., 2009.

Raman spectrometer

The Raman microscope incorporated into the system offering optimal confocal spatial and depth discrimination, multiple laser/detector options, and automated XYZ mapping.

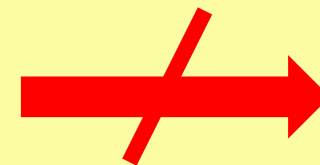
Software

All Raman and FTIR functions are controlled by a single comprehensive software package: [LabSpec 5](#)

Prospects for MAP Production ?

Despite of all biological and technological achievements
the plant factories for MAPs will remain to subject of

**Industrial scale field production and
processing.**



Example to follow:

<http://www.rirdc.gov.au/>

Plant Industries Australia



The screenshot displays the RIRDC website header and a featured research program. The header includes the Australian Government logo, the RIRDC logo, and navigation links for News & Updates, Subscribe, and Home. Below the header is a secondary navigation menu with links for About RIRDC, Research Programs, For Researchers, Publications, and Rural Women's Award. The main content area features a large image of pink flowers with the text "A szöveg helye" overlaid. Below the image is the title "Essential Oils and Plant Extracts" and a breadcrumb trail: Home > Research Programs > Plant Industries > Essential Oils and Plant Extracts. At the bottom, there is a "PROGRAM OVERVIEW" section with a horizontal menu containing links for OVERVIEW, PRIORITIES AND DELIVERABLES, PERFORMANCE MEASURES, R&D PLAN, and KEY CONTACTS AND LINKS. A "HIDE" button is located at the bottom right of this section.

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Rural Industries Research and
Development Corporation

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A szöveg helye

Essential Oils and Plant Extracts

Home > Research Programs > Plant Industries > Essential Oils and Plant Extracts

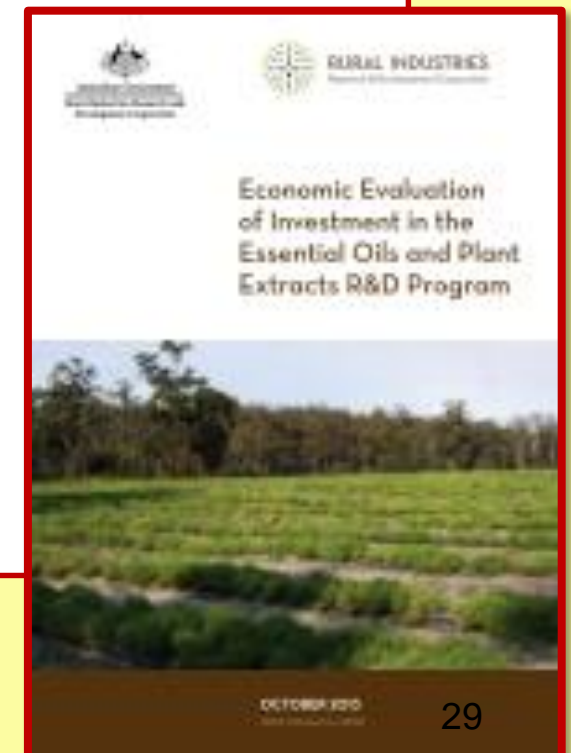
PROGRAM OVERVIEW

OVERVIEW | PRIORITIES AND DELIVERABLES | PERFORMANCE MEASURES | R&D PLAN | KEY CONTACTS AND LINKS

HIDE

Key long-term strategies for the Essential Oils and Plant Extracts Program

- **Improve production systems** to raise productivity and control over product qualities.
- Support **new ideas** that provide potential for growing the market for Australian product.
- **facilitate** the satisfaction of **regulatory requirements** to enhance market access.
- Support the **demonstration of safety and effectiveness of Australian products**
- **Improve the industry and research capacity.**



Tasks for the Future:

Strategic development of

- ≡ large scale production in a
- ≡ sustainable way
- ≡ according to GACP, GMP, FairTrade, etc.

Special focus on:

- ≡ Quality
- ≡ Safety
- ≡ Efficacy



Pyrethrum production in Tasmania



Thank You for Your Attention