Science & Technology For the Future: Nature Versus Economy?

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In memoriam Prof. Emeritus Vera Johanides

Introduction: a dedication

Looking back in anger seems to be not at all modern nowadays. Nevertheless it is quite fascinating to look back to the internal development of biotechnologies during the last decades. Starting point of this overview is the time, when I started my academic carrier in S&T in the year 1969. At this time my old professor *Georg Gorbach* was dying. The first famous person I met was *Vera Jahanides* in Oxford in 1974. She directly promoted me because of the fact that she was very familiar with Gorbach and Graz and that she also belived in similar approach I followed in my thesis on nature-near tubular bioreactors. Since this time Croatia and Zagreb has always been near to Graz; our contacts never received official background but have been quite intense because of private friendships with *Vladimir Maric* and *Predrag Horvat*, who was working within my group in Graz quite a long time what resulted in a fine number of joint publication even on tubular reactors.

The thinking behind this work was always to promote nature's wisdom within the field of biotechnologies, elucitating bioprocesses with the aid of mathematical modelling of the processkinetics or designing tubular bioreactors for diverse bioprocesses. This approach encounters a renaissance in the time, where nature becomes the model for new technologies (eco-tech, bionics) but also for economy (natural capitalism acc. to Hawken & Lovins form USA, eco-social market economy acc. to Riegler form Austria). Thus looking back is helpful and, therefore, I dedicate this article to *Vera Johanides*.

Main questions: For the future

What is future, just the on-going time? Is it identical with time?

What is science, just doing measurements on any subject or object?

How do we understand technology, just doing what we can do?

Isn't life raped in modern biotechnology; is there an alternative?

Can we understand life and nature just using a mechanistic approach?

Do we have lost the deep feeling for the wonder of life in any form?

Will we be able to unearth nature's treasure without destroying it?

Is a living system just an agglomeration of several proteins?

The new faith in science, can it really replace faith in God?

Isn't there a deep connection between aesthetics & technology?

Is it impossible to bridge over the gap between technology & ethics?

Isn't ecology quite similar to economy when it looking to nature?

Is there no chance to reconcile anthroposphere with ecosphere?

What type of economy, technology & science would we need then?

Methodology: As it is and as it should be

The world as it was: Thinking in terms of efficiency

The roots of this first approach in economy are in the early industrialization starting the so called 1st industrial revolution. *Henry Ford* stated in 1926, that "you must get the most out of power, material and time". This is already the definition of efficiency as economic performance: "doing more with less" i.e. using less raw materials for production of more products. The advantages are clear and they have been strongly wanted by society: to bring more goods & services to larger number of people in order to raise the standards of living and to give people more choices.

However, the disadvantages has become clear step by step: the loss of biodiversity of any kind, an increasing gap between rich & poor and the replacement of ethics by the free market rules.

These facts lead to the next innovation of eco-efficiency.

The world as it is: Thinking in terms of eco-efficiency

Its roots are in documents from United Nations Commission for Environmental Development (1987) in "Our common future" and within World Business Council of Sustainable Development (1992) "Changing course" defining eco-efficiency as "combined economic & ecologic performance creating more value for the benefit of both". Thus to use fewer resources & to release less pollution, to use more renewable mass, to minimize irreversible impacts on health of man & nature and to be competitive, sustainable successful in the long run. Stephan Schmidheiny, the founder of WBCSD stated in 1996 that "it will be impossible for business to be competitive without being eco-efficient!"

The success story of eco-efficiency contains the popular "3R' s": to reduce, to reuse and to recycle, which was followed by the well known industries like 3M et al. Thereby the technology paradigm was that of Cleaner Production resp. "Zero Emission".

However, also as this was a step forward, several drawbacks became obvious: the eco-efficiency concept is successful as long as it focuses on short term and still within the same system causing the problems. It is not sufficient with a "factor 4+"[12] in case of toxic materials; it is slowing down due to moral proscriptions & punitive demands and it deals only with "win-win" situations.

Thus, eco-efficiency is not more than an illusion of change as it is fixed to the unchanged boundaries defined by capitalism with pure competition: eco-efficiency is not "deep enough" as other, better boundaries (like eco-social); they cannot be incorporated even with the strongest regulations made by governments.

Comparison of efficiency and eco-efficiency:

Efficiency revolution:

1. putting great amounts of toxic materials into air, water, soil

2. endless regulations needed to protect people & nature

3. prosperity measured in purely materialistic terms

4. eroding biodiversity and the gene-pool.

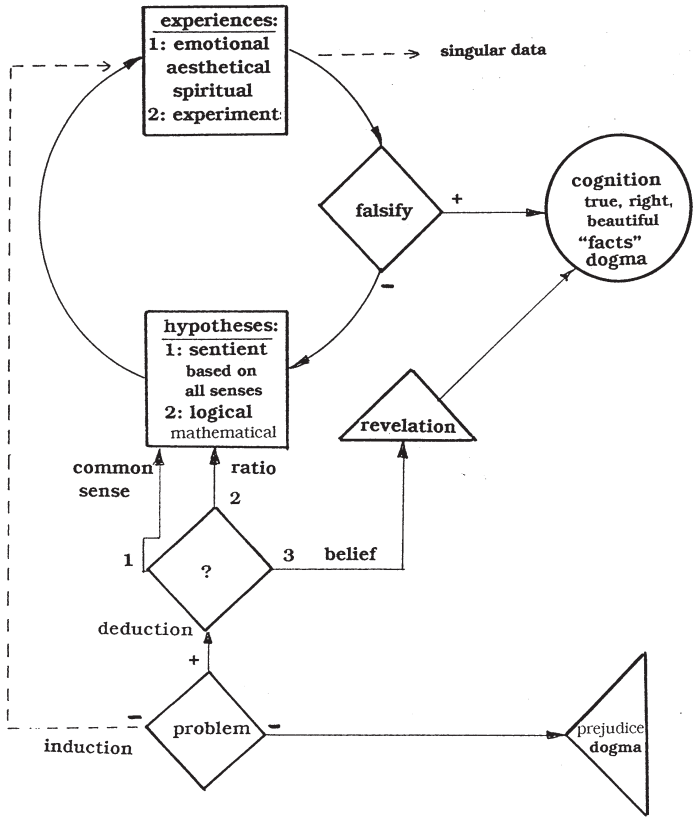
Eco-efficiency revolution:

1. releases fewer toxic materials, which is – in the case of high toxics, clearly not enough: Earth (air, water, soil, plants, bodies) is increasingly polluted by newer and the newest chemicals (10.000/year) while 100 are checked with technology assessement by EPA. Due to increasing overall growth more wastes in total are made

2. even more regulations are needed

3. prosperity still measured in purely materialistic terms

4. homogenizes biological species but cultural practices also.



F i g 1 – *The conception of "Deep Sciences". The fundament of sciences is a three step process: 1. setting-up hypotheses 2. collecting experiences 3. comparing 1 with 2 in order to falsify hypotheses.*
Conventional "hard" sciences have restricted experiences only to measurable experiments resulting in a reductionistic world view. Holistic "deep" sciences include experiences from all senses into the set-up of adequate hypotheses. At the same time true revelation is accepted as path towards cognition, while dogmas (from religion as well as from sciences) are to be questionned as long as they show their validity. The breakthrough of hard sciences started in the 16th century based in the methodology of induction (resulting in only singular data), which is replaced continuously by the described method of deduction. In the scheme[6], three paths to achieve cognition are mentioned: the scientific sense and the common sense both based on deduction and the belief based on revelation.

The world as is should be

Based on the above statements and critiques on the efficiency approach some people were looking for a "next industrial revolution".

– globalisation is recently seen as a "project against all that, which was developed during the last decades in respect to democratic, social & political progress" as pronounced by *Jörg Huffschmied*, an economist on the meeting "Das andere Davos" (2001): They founded a *World Social Forum* instead of the World Economy Forum i.e. a "global resistence community".

– "*L'Economie populair*" as informal sector; the economy of people resulting from the forces of selforganisation leads e.g. to 60 % of GNP in Senegal and Ghana

– approach called "Natural Capitalism"[8] with some principles: increased resource productivity; "biomimicry": closed cycles, no wastes; from product to function; re-investing in nature

– New social efforts by the Nobel prize winner Amartya Sen[9] with the principles: socially balanced economy, justice & solidarity; freedom as basis of justice and social obligation, poverty as lack of chances for selfrealisation: crises in democracy and other principles

– "Eco-Social Market Economy" according to *Josef Riegler*, the former vice-chancellor of the republic of Austria[11] having its roots in a concept from activists for nature in Austria (ONB, 1976).

The path of its success started in Styria, 1979 and led to the signment of it by all agro-ministers of EU in 1997!

Characteristics are new eco-social boundary conditions on the outside and a new pattern of behaviour inside, in form of "fair" and not "free" market, containing not only competition but also neutralism, comensalism and symbiosis.

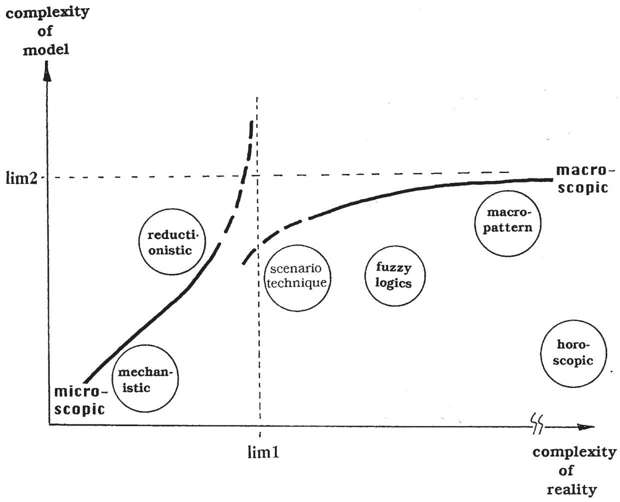
All these innovations have their common roots in nature. Thus, it should be of greatest interest to see what we can learn from nature.

It is nice to see that this path is followed on several levels: a new book on the wisdom of nature will be edited soon[13] and the next World Expo in Aichi/Japan will deal with "Nature's Wisdom".

Thinking in terms of effectiveness

It is astonishing that nature is not efficient but effective: a tree is not only producing fruits but it serves at the same time a diversity of aims for its environment (insects, birds, soil etc). Thus, the question is: what can we learn from nature? The answer is:

Eco-Effectiveness, which is a regenerative and not a depletive system being interdependent with other living systems. As a result we should not focus on cradle – to grave, but on "cradle -to- cradle" when considering life cycle analyses. Even if the term effectiveness seems clearer now, a full understanding can be achieved when we follow the path of the "wisdom of nature"!



F i g . 2 – *The conception of "macroscopic pattern" as addition to the conventional microscopic approach from mechanistic sciences.*
In case of higher complexity of the model needed for complex phenomena, a limit (lim 1) exists for adequate description, which cannot be surpassed. In the range of highly complex systems other methods have been developed e.g. scenario technique (a series of varied assumptions), fuzzy logics (verbal formulations), horoscoping (only low probability for too complex systems) and the macroscopic pattern analysis (significant phenomena on macroscopic level) decribed here. Especialy the macroscopic pattern methodology is very powerful for describing complex systems like hurricans, monsoon, avalanches and bioprocesses in industrial scale bioreactors[4,5]. Here another limit exists, lim 2, representing the maximum number of estimatable parameter inside a mathematical model.

Strategy of "what to learn from nature"

Three steps are to be distinguished when following the path:

i) to look at nature in its "macroscopic pattern" representing an innovative approach in analyses[3,4] containing 4 facts:

1. biodiversity leading to limits for each individual species

2. interactions between the diversity leading to networks

3. selforganisation (S.O.) leading to an evolutionary development

4. the result, then, is life in all its diversity.

The concept of macroscopic pattern analysis is depicted in fig. 2.

ii) to derive working principles called "eco--principles" with aid of an innovative concept of "deep science"[5,6,7], see fig. 1.

The essential consequence of this effort is "wisdom" with 4 steps:

1. 1st principle of cognition: to obey the limits as the consequence from diversity means the principle of SUFFICIENCY

2. 1st principle of action: based on sufficiency it becomes clear that inside the limits we have to follow the principle of EFFICIENCY to do the best

3. 2nd principle of cognition: to fit into existing networks as a consequence from interactions means the principle of EMBEDDEDNESS

4. 2nd principle of action: based on embeddedness it becomes clear that we will not destroy our carrying capacity on the ecological as well as social level: this is the principle of NON-INVASIVENESS.

Finally, in case that these four principles are followed, the preconditions are given, so that we can become creative (S.O.), governed by phantasy, which means that we will be:

1. selfreliant in thinking & feeling i.e. autocatalytic

2. able to work & to risk i.e. not in thermodynamic equilibrium

3. open to environment i.e. a flow through the whole system.

Thus, life can evolute in nature as well as in society according to S.O.!

iii) to transfer to anthroposphere: the eco-principles are valid for eco- & anthropo-sphere[7,13]

How to measure eco-effectiveness

For this purpose a new currency must be found as money is of no value for the dimension of ecology and the socio-cultural aspects of human societies. The Club of Rome discussed 1995 in the book "Taking nature into account"[10] the need and structure of the so-called "Eco-Social Product" (ESP) without being able to give a mode of calculation. They started with a Sustainable national account/ income (SNA/SNI). ESP should replace Gross National Product (GNP) which mirrors only the flux of money. The first index of sustain-ability was the Index of sustainable Economic Welfare (ISEW) from Daly & Cobb, which however, is too complicated in application: Needed is an index for strategic rapid use in a simple but adequate form. It must be a 3-dimensional index for the economic, ecological and social aspect of sustainability.

This new currency was identified as the eco-active area of soil being the bottleneck on Earth leading to new indices like the ecological footprint ACC, the Sustainable Proces Index (SPI) and the (SLSI), the sustainable Livelihood Security Index[3,6]. Based on this currency, eco-effectiveness can be quantified. The difference between other well known indices like the MIPS, the Material Intensity per Service, is, that the dimension of MIPS is the mass per service, thus, it is of no direct meaning for ecosphere!

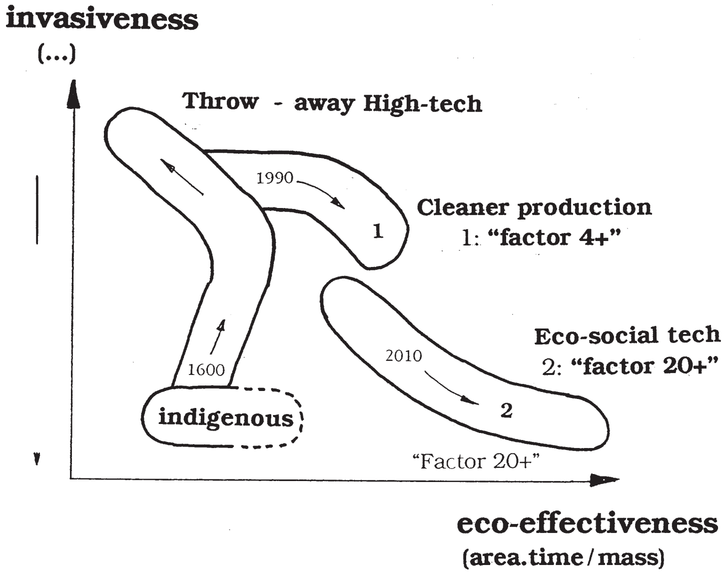


Fig. 3 – *Differentiation of diverse technology paradigms using eco-principles: a plot of invasiveness versus eco-efficiency shows that the development of human efforts started with indigenous, nature-near technologies, leading to the design of high-tech, which, however, is mainly used once, and so can be called throw-away technology. The modern approach in cleaner consumerism is cleaner production, where the mass cycles are closed as much as possible (with an economically fixed limit), where reduction factors of 4+ (up to 10) are achievable.*
Based on a change in awareness the new paradigm is based on holistic boundaries in the form of eco-social technology, which will result in the highest reduction factor of 20+! Thus, a direct correlation exists between high values of eco-effectiveness and low invasiveness!

While MIPS gives only a relative value, indicating a relatively better or worth effect, ACC, SPI and ESP directly show some concrete value for the ecosphere and the other dimensions, as results of calculation. MIPS and others can be regarded as indices measuring the eco-efficiency, but not the eco--effictiveness! Fig. 3 illustrates this statement in a plot of the eco-principle of invasiveness against eco-effectiveness allowing the differentiation of technology paradigms:

– Throw-away High- Tech is modified in the Cleaner Production paradigm in such a way, that it is closing the cycles of mass as much as possible (mass recycle needs energy, thus, an optimum recycle rate exists, which is about 80 %!).

Thereby a reduction factor for the input of wastes to nature in the magnitude of 4+ (resp. is in maximum) can be achieved. This result is realized directly with existing industries.

– Eco-social Tech, as it is based on a changing awareness and consciousness, results in reduction factor 20+! Thus, it needs time and education based on "deep", holistic sustainability.

Sustainability

Sustainability as the new world view seems to be well known, even if it is not yet at the point of a breakthrough although there is no way out for this new view. One explanation of this contradiction is, according to the authors' conviction, that the decisive factor in it is not fully experienced, as sustainability at present is on a "shallow" level because it contains only superficial dimensions. Thus, two types are to be distinguished, the partial and the holistic sustainability.

1. "shallow"/partial includes economic, ecologic and social dimensions. Its foundation is eco-efficiency based on existing type of economy, the "free" market. However, it is surely necessary, but not sufficient in the long run; it is represented only as a transition to final sustainability, but it is a very useful bridge between diverse sectors.

A typical index of shallow sustainability is the MIPS, the material intensity per service (mass/service).

2. "deep"/holistic is based on eco-effectiveness, which contains, in an overall integrated manner, eco-efficiency, sufficiency, embeddedness and non-invasiveness.

The basis, thus, are the "eco-principles" from nature, which can be transferred to anthroposphere as "eco-social" principles resulting in the "eco-social market economy" as the new type of "fair" economy. As typical index "Eco-social-Product" (ESP) is used having the dimension of eco-effectiveness i.e. area of eco-active surface of soil. Deep sustainability has 5 dimensions i.e. economic, ecologic and social plus ethical & aesthetical aspects together with time! This statement has a certain background: already the old cultures in China in their wisdom and later, the greeks, discussed the world in three dimensions: the true, the right, the beautiful. This was recently supplemented by "the collective" according to Ken Wilber. Thus, ethics and aesthetics are integral part of the whole: "aesthetics is the mother of ethics" is one sentence and "ethics is just the insight into the whole", another one in this sense. If sustainability should restructure the world, this concept has to contain all aspects of the world! Time is the chance to go in the right direction!

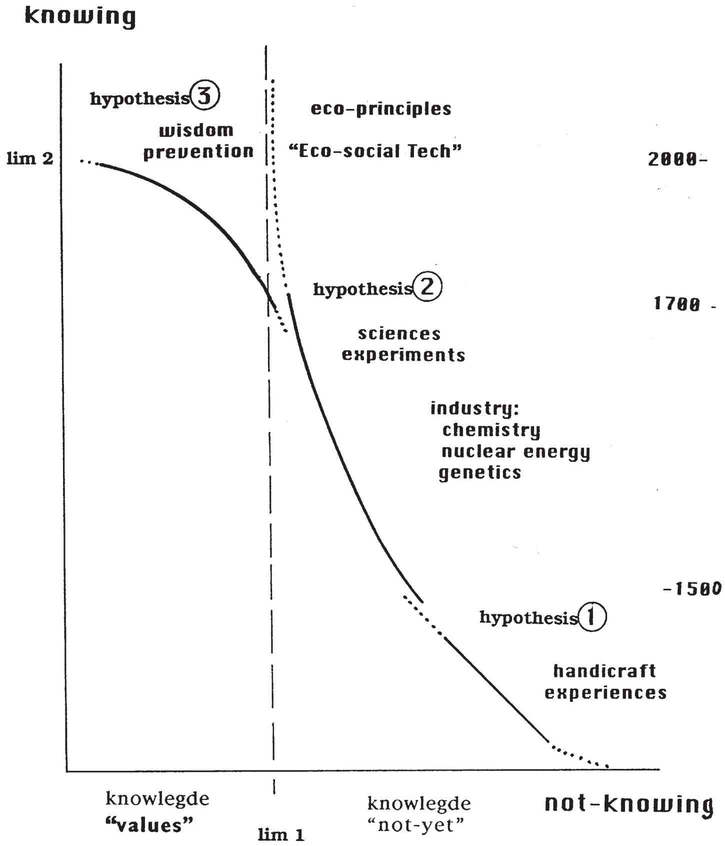


Fig. 4 – *Scheme of the progress in gaining cognition in past and future plotting knowledge versus the "non-knowing", where two parts can be distinguished: the "not-yet" knowledge and the "never knowing", which are the ethical values. The first working hypothesis of man kind was the handicraft approach based on integrated experiences it made: increase in knowledge resulted directly in decrease of the not-knowing. With the start of the 1st industrial revolution in the 16th century, this was prolongued leading to the situation nowadays, that hard sciences, according to fig. 2 are exponentially growing, but the not-knowing has not been decreased: a limit (lim 1) exists, as ethics seen as the supplement of sciences since the time of Immanuel Kant! The third phase in this development is given by the use of nature's wisdom demonstrated here*[13]*: based on the eco-principles, the progress in knowledge incorporates ethics in the form of sufficiency and non-invasiveness, what results in the possibility still to increase knowledge, but not to neglect the decrease of the not-knowing, so another limit exists, lim 2, indicating a final general limit in cognition!*

Case studies on S&T: "Forward to future"

Eco-Tech towards sustainability

Understanding sustainability in the deeper dimension results in the design of adequate technologies. Several terms are known in this respect: "Sus-Tech", "Zero-Emission", "Industrial Ecology", "Eco-Tech".

While sus-tech is used just as a term, while it is still in the order of magnitude as cleaner production, zero emission is different: it can be an illusion as it is utopistic with zero wastes, however, it is often understood in the same way as ecotech. Industrial ecology is a new attempt to reduce the impact on nature, thus, it is basically a methodology and not a technology. This means, that it is a part of existing economy and therefore can not solve the problems we will have in future. Only eco-tech can as it is based on the eco-principles!

In order to illustrate the problem solving capacity of eco-tech, a case study is shown here, evaluating eco-tech as real contribution to deep sustainability. Thereby, an innovative index of deep sustainability is used, the ESP. This case is a comparison between renewable vand fossil energy to be used for a city with 10.000 inhabitants in Styria, as demonstrated in Tab. 1.

Table 1 – *Comparing renewable energy versus fossil fuel with ESP*

Renewable		Fossil	
1. ecological index (m^2 kg^{-1} a^{-1}) based on SPI (TU Graz)			
15 ± 9		440 ± 60	thus: f_{ecol} > 50
2. social Index (jobs/area)			
135		9	thus: f_{soc} > 10
3. economic Index (% money/area)			
0	export	59	
48	national	25	thus: f_{econ} > 3
52	region	16	

From the table it becomes clear that such a transition from fossil crude oil to renewable materials like timber from the forests growing in the region, can solve the ecological problem with a reduction factor of > 50, the social problem by creating jobs with a factor > 10 and even the economic problem by saving money with a factor > 3!!

A great number of good ideas and even proven technologies is compiled in Tab. 2.

As a general conclusion of this list it becomes evident that genetic engineering is not the only source of techs for the future: the main treasure of nature still is to be unearthed in the time resulting in intelligent techs exhibiting the trend shown in Fig. 3: highest eco-effectiveness at lowest invasiveness, which is not the case with genetic engineering! Nevertheless it is to be added in this place, that genetics would play an essential role, when this methods will be embedded into the eco-social boundaries i.e. when the ecological as well as the social consequences will be included into research & development, needing more time & money based on new awarenes.

Ecological bioreactor design

After first part dealing with the design of technologies in general terms, another part of the story will be discussed below, which is directly connected to bioprocessing. This is the case of designing bioreactor system in order to fulfill the deep requirements of bioprocesses according to the intrinsic kinetics of the natural processes representing so-to-say the treasure of nature! Fig. 5 illustrates this deep interconnectedness between reactor design and biokinetics as an alternative process design. This methodology of following the "wisdom of nature" is not economical in capitalism at present as it is not focusing only on efficiency but on holistic terms of effectiveness.

Table 2 – *Technologies with a very high capacity to contribute to sustainability*

i) "Bionics" taking mechanistical structures in nature as models:	
human arm	robotics
joints	flexibility ropes, no gearing (-70 % mass)
birds plumage	ventilators (more buoyancy)
termites	aeration/heating (effective ventilation)
bats, dolphines	sonography (orientation by ultrasound)
plant stalk	car-body
honeycomb	bracings (higher firmness)
birds	airplane (no cross turbulences, frictionless: "winglets" at the end of a wing
green algae	energy, H_2
dolphines	ships (head swelling: less friction: streamline)
shark	ships (rough skin: less friction hull submarines
silk	ropes
algae	bones (enhance bone growth: implanted tooths)
snakes	cross country sky (anti-glide skin)
trees	construction
chlorophyll	solar cells: green Ru pigment: -80 % costs, 11 % conversion in 20a R&D (Si-cells: 16 % in 40 a)
ii) phyto-techs:	
starch materials, proteins, fats, fabrics, wax, resines, dyes, tannin, phytopharmaceuticals, cosmetics, saponines, insectides, ocean derived products	
iii) eco-techs/biotechs:	
biofertilizer (*rhizobia*)	
biopesticides (*Bac. thuringiensis*)	
biopolymers (e.g. pHB) as plastics	
"green biorefinery" (biologicals from agricultural mass, exhibiting an increasing market at decreasing prices)	
phyto-pharmceuticals: phytoestrogen, sugar substitutes	
desulfurization of coal	
denitrification of water	
enzymes instead of chemical catalysts	
animal & plant tissue cultures	
bioleaching of ores (Cu, U, Au)	

Tubular reaction vessels are found in nature quite often i.e. the transport tubes in plants and animals for water and blood, rivers and even the construction inside mitochondria are tubes.

The advantages of continuous tubular reactors (CTR) compared to continuous stirred tank reactors (CSTR) are[14]:

– higher surface to volume ratio enhancing heat and mass transfers

– higher conversion rate at optimal productivity for reaction order higher than zero, which is the case with bioprocesses

– realization of gradients is clearly possible with the consequence that substrate and other concentrations can be handled in case of substrate inhibition resp. production repression (cf. fig. 5). This means that the dosing of raw material and oxygen can be optimized as indicated in fig. 5b as well as yielding the product or CO_2.

– final degradation of concentrations can be easily achived at a longer tube systems thus, wastes are reduced to minimum without a loss in productivity

– continuous manufacturing of products in a stationary growth phase is practicable, which is the case with secondary metabolites

– sterility is easier to realize as through-flow exists.

Horizontal tubular reactors HTR exhibit additional advantages:

– strongly enhanced mass transfer as no gravitation exists (k_La up to 2000 h^{-1} can be achieved at 10 Watt per liter compared to the value of 1000 h^{-1} at 30 W/l in STR!

– reduced foam formation due to the same effect

– process control is also facilitated due to the fact that the process is proceeding with length of reactor!

During the last decades a series of experimental verifications have been realized at TU Graz in the continuous mode of operation (HTR):

1. beer brewing in a 5 meter tube systems with a diameter of 5 cm resulting in the highest quality product due to the fact that the taste compounds are formed in tubes in a similar way as in conventional batch processes!

2. production of ethanol with *Zymomonas mobilis* in a tube system with 4 meter lenght and 15 cm diameter with significant results as mentioned before and quantified in Tab. 3.

3. production of biotoxins with *Bacillus thuringiensis* in the same pilot plant horizontal tubular reactor with some significant results:

i) the formation of the exotoxine is not associated with growth but exhibits a certain maturation time, which can be realized in a tube easily. It was nice to see that the living cells diminished after a length of 1.5 meter while the spore formation started after a lenght of 2.5 meter!

ii) in the stationary growth phase the spores containing the toxine are formed, which can be practically realized in a tube

iii) the conditions in respect to growth and sporulation are quite different so that the dosage of medium can be adapted to it.

Table 3 – *Data of continuous production of ethanol in HTR with Zymomonas mobilis strain compared to data in CSTR*

	CSTR	HTR
conversion %	98	98
dilution rate, h^{-1}	0.07	0.3
productivity, $kg \cdot m^{-3} \cdot h^{-1}$	3.4–4.5	6.5–8.5

Conclusions: "back to nature"

Although the particular facts from the case studies became quite clear, a number of general points have to be mentioned at the end.

1. Factor problems:

It must be clarified, what order of magnitude of known problems we expect in the future. *Jansen* et al. calculated in 1992, that the load to ecosphere (L) depends on 3 factors: population (P), welfare (W) and consumption by technologies (T) for supplying P with W:

$$L = P \cdot W \cdot T \quad (1)$$

Thus, in order to keep the load to nature at least constant we must design technologies able to compensate the increase in P and W (1 – 2 % per year each). In this way it is quite plausible that we need technologies with a reduction factor of 20 to 50 in the year 2030! The situation at present is, that technologies with "factor 4+" are avaliable (cleaner production, see book of *Weizsäcker* et al. 1995[12]). It is agreed that a factor of 6 (up to 10) is the maximum in this paradigm of direct implementation of existing technologies without a change. Thus, we can conclude, that we have to initiate a change!

2. Factor time:

How much time do we have to start-up this change? At which time we should begin with the changes in structure and consciousness?

To find this answer, characteristic times can be calculated

– from young people in school to director in high position: 20 years

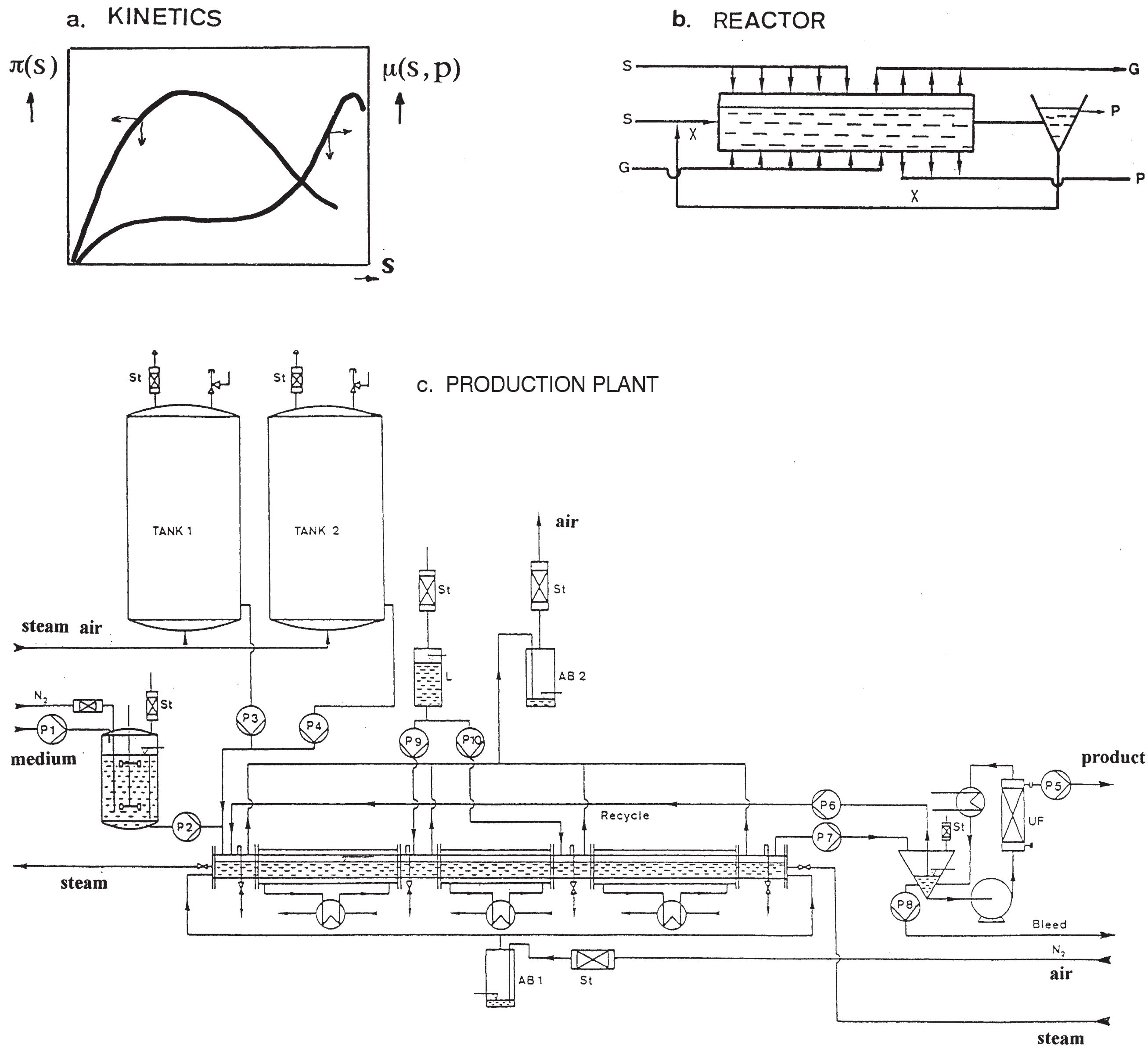
– from a good idea over R&D to a product on the market: 25 years!

Thus, we have to start just now to be ready in 2025!

3. Factor consciousness

How should we begin this transition in awareness & consciousness?

What do we know about the formation of consciousness?



F i g . 5 – *Scheme of designing a nature-near bioreactor system in order to let the bioprocess develop according to "inside rules of nature" given the kinetics (a) shown: growth exhibits substrate inhibition and product inhibition resulting in μ(s, p), with a repression type of product formation π(s). The optimum type of an "ecological" bioreactor is then a tubular reactor (b). Such systems are used years ago in Graz for the continuous production of ethanol with Zymomonas mobilis and the continous production of bioinsecticides with Bacillus thuringienis (c).*

According to the Austrian psychologist Viktor Frankl (logotherapy) and other schools (R. Assagioli: psychosynthesis) consciousness (C) is built with the aid of three factors:

$$C = E \cdot I \cdot S \qquad (2)$$

E = energy, inside ourself based on selforganisation (S.O.)

I = information coming from outside

S = all six senses, needed to select what is essential for man.

Thus, in order to manage the future, we must learn:

– to support the forces of S.O. by teaching 1. to think & feel independently, 2. to be able to work and to risk and 3. to be open towards the environment

– to supply people with significant information (transition from "information society" to "knowledge society" and finally to "cognition society" where science and ethics are integrated)

– to "feed" all our senses by experiences in order to become affected.

Einstein stated long before: "The world cannot be saved by the same mode of thinking, that created the problems we encounter".

Keywords:

Future, deep sustainability, eco-tech, eco-social market economy, nature's wisdom, eco-effectiveness, deep sciences, macroscopic pattern, biomimicry

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