

Developing a Green and Sustainable Pharmacy



VISIONS • STRATEGIES • BEST PRACTICES
HEALTH EXECUTIVE SUMMIT



Klaus Kümmerer

Klaus.Kuemmerer@uniklinik-freiburg.de

**Department of
Environmental Health Sciences**

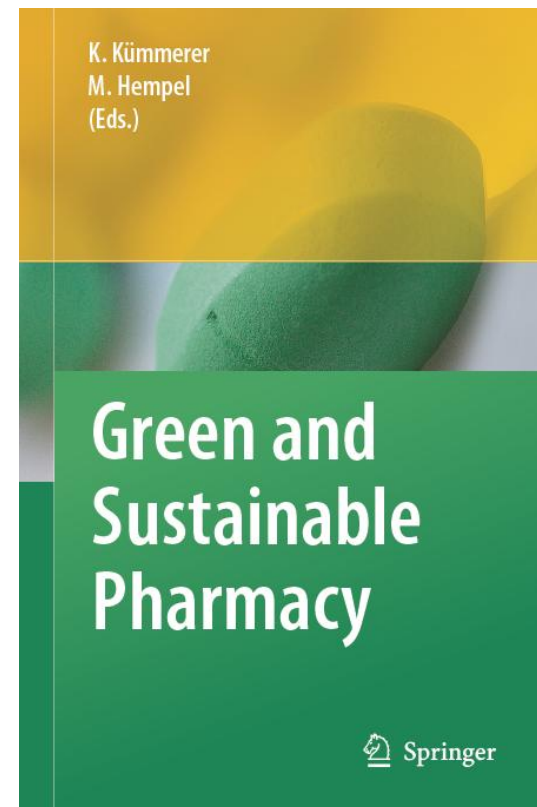
UNIVERSITY
FREIBURG



HOSPITAL

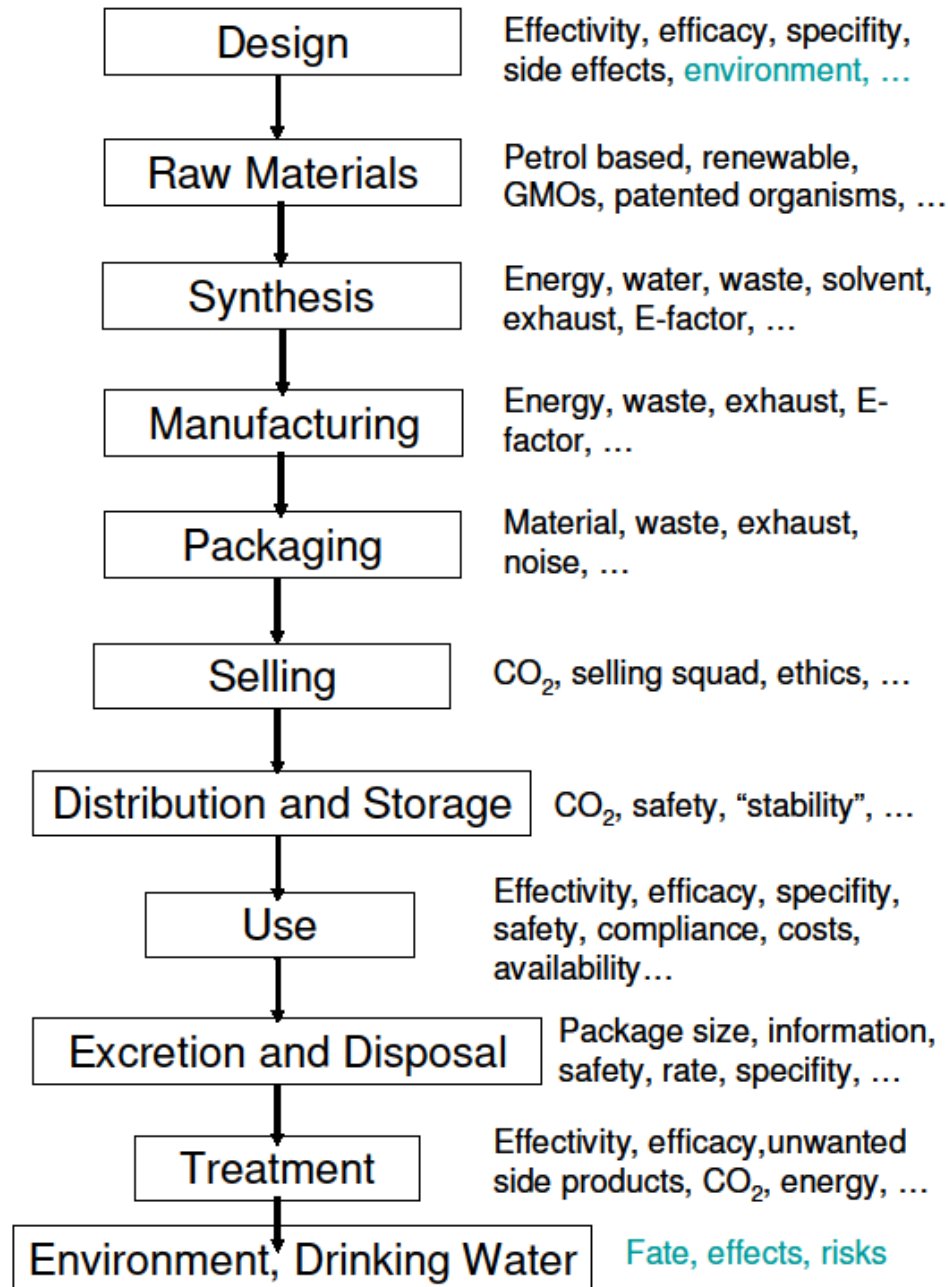
General Aspects

- New, emerging topic
- Big opportunity
- Relationships and interconnectedness with Green/Sustainable Chemistry
- Discussion in Europe ahead of the U.S. (except synthesis optimization)



Sustainable Pharmacy

Sustainable Pharmacy includes all aspects related to development, production and use of pharmaceuticals along all stations of their life cycle that aim to minimize all undesired effects including health, environmental, social, cultural and political effects.



Raw Materials

- **The future: petroleum based raw materials? Renewable feed stocks?**
- **New platform molecules?**
- **Issue of patenting of organisms!**

Environmental Impact of Synthesis

$\frac{\text{kg (waste + by products)}}{\text{kg products}}$

	Production (t / year)	E-value
Oil refinery	10 – 10	ca. 0,1
Bulk chemicals	10 – 10	<1,5
Fine chemicals	10 – 10	5 – 50
Pharmaceuticals	10 – 10	25 - >100

 Sheldon E, Green Chemistry, 1994, 2007

Emissions Related to Manufacturing

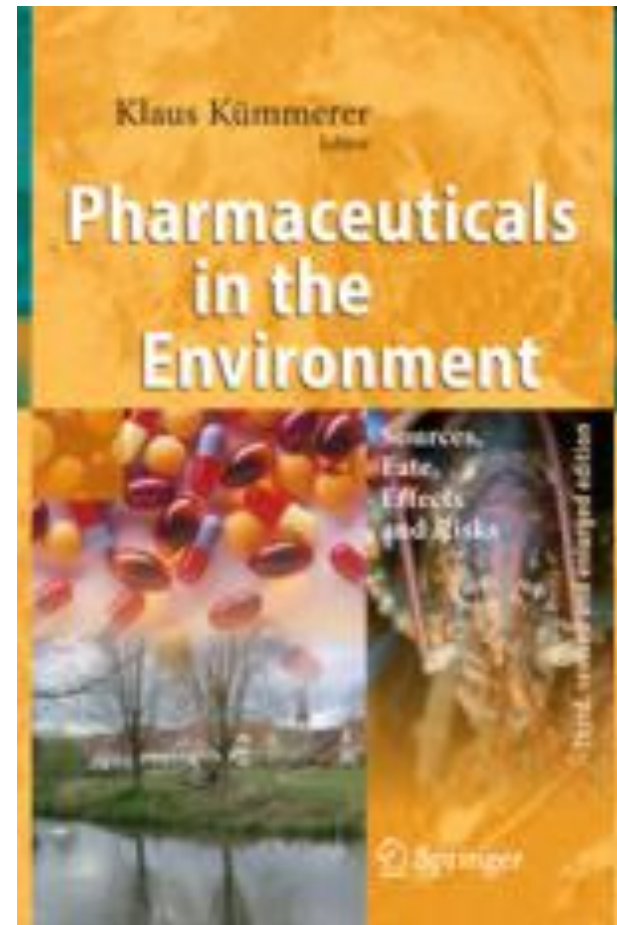
- Europe, US: in general low emissions
- India (Larsson et al. 2007)
- China (Li et al. 2008)
up to mg/L !!!!!
- Africa ???

Use

- **Out-Dated, Reminders:
10-35% down the drain/waste**
- **Compliance!**
- **Resistance (antibiotics, anti-neoplastics)**
- **Availability**
- **Efficacy, effectivity**
- **Alternatives (e.g. anti-pain therapy)**

After Use

- **Excretion rates: 5% - 95%**
- **Pharmaceuticals are present in the aquatic environment (ng/L- μ g/L)**
- **Effects detected (fish, vultures, ...)**
- **Humans?**



Risk Management Strategies (1)

1. Technology
(Advanced) effluent
treatment

short to mid-term

Obstacles:

- Technology limited
- Reaction by-products
- Not all waste water treated
- Energy demand
- Not possible/
affordable in less
developed countries

Not sustainable

📖 Jones et al. (2007) Environ. Sci. Technol
41:5085-5089, Wenzel et al. (2008) Water Sci.
Technol. 57:27-32

📖 Kümmerer (2007) Green Chem. 9, 899

Risk Management Strategies (2)

1. Technology

(Advanced) effluent treatment

short to mid-term

Obstacles:

- Technology limited
- Reaction by-products
- Not all waste water treated
- Energy demand
- Not possible/
affordable in less
developed countries

Not sustainable

📖 Jones et al. (2007) Environ. Sci. Technol
41:5085-5089, Wenzel et al. (2008) Water Sci.
Technol. 57:27-32

2. Behavior

Usage:
patients, doctors,
pharmacists

mid-term

Obstacles:

Needs time

**Not for
administered
share of drugs**

📖 Kümmerer (2007) Green Chem. 9, 899

A smart person solves a
problem.
A wise person avoids it.

Albert Einstein

After Use Life

**(Complete, fast) degradation
after use is part of
life cycle functionality!**



Readily (bio)degradable APIs



No Exposition



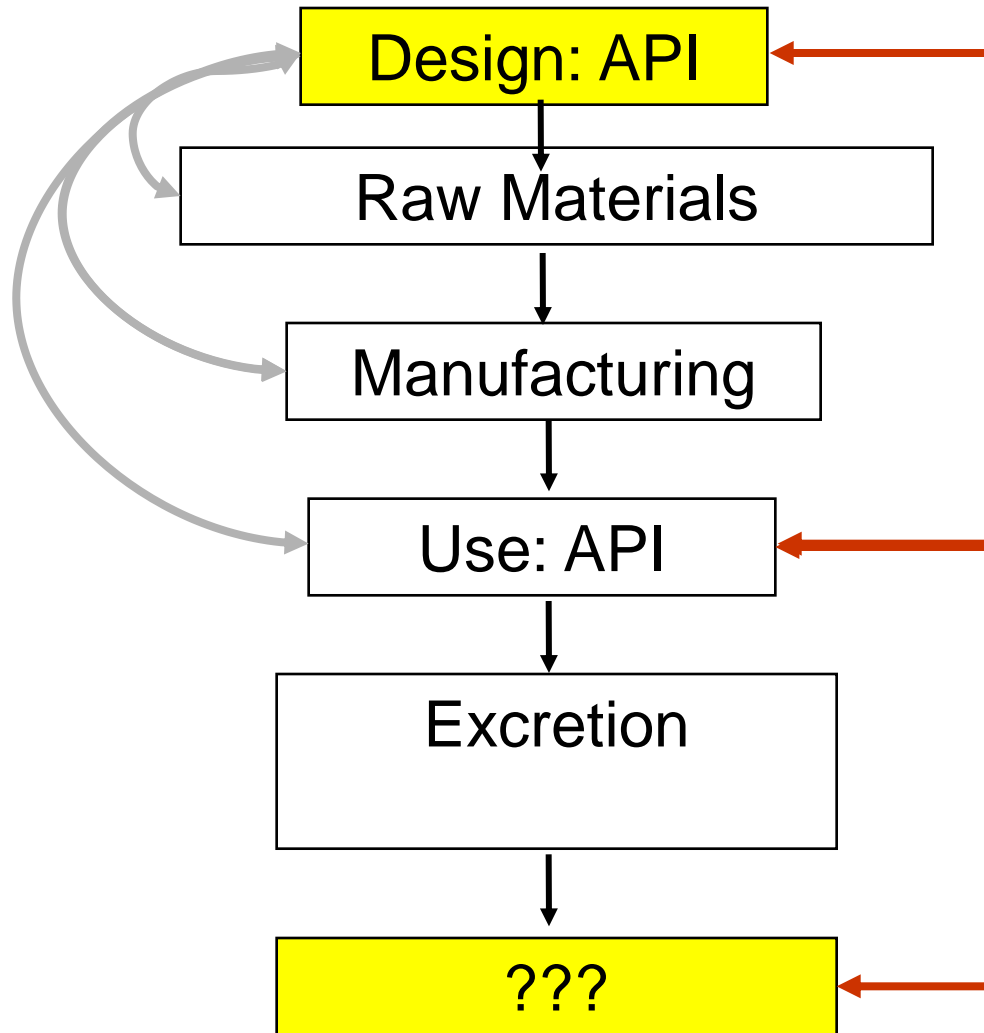
No Effects, no risk

Functionality of a Pharmaceutical “Sustainable View”

Full life cycle considered:

- high oral absorption
- effective and efficient
- receptor specific
- reduced/no unwanted effects
- metabolized to harmless metabolites
- ...
- **Degradability after use is part of functionality**

Life Cycle of Pharmaceuticals



**The end
already
always
in mind!**

**Benign – by
Design**

Risk Management Strategies (3)

1. Technology

(Advanced) effluent treatment

short to mid-term

Obstacles:

- Technology limited
- Reaction by-products
- Not all waste water treated
- Energy demand
- Not possible/affordable in less developed countries

Not sustainable

📖 Jones et al. (2007) Environ. Sci. Technol. 41:5085-5089, Wenzel et al. (2008) Water Sci. Technol. 57:27-32

2. Behavior

Usage:
patients, doctors,
pharmacists

mid-term

Obstacles:

Needs time
Not for administered share of drugs

3. Active compounds
substitution of critical compounds

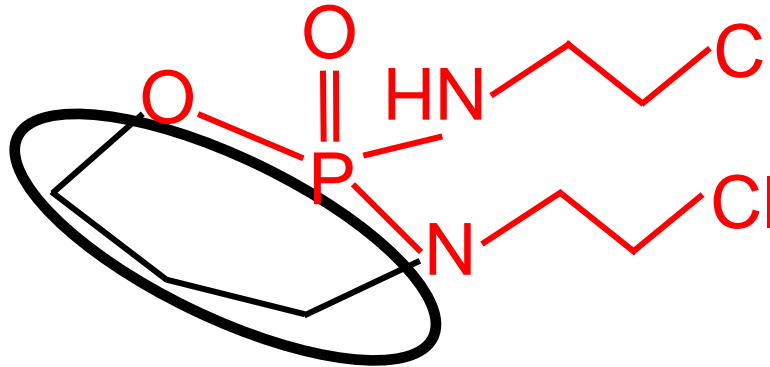
benign by design
long-term

**Smart solution,
opportunity of the future**

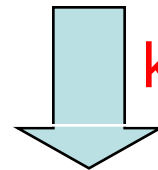
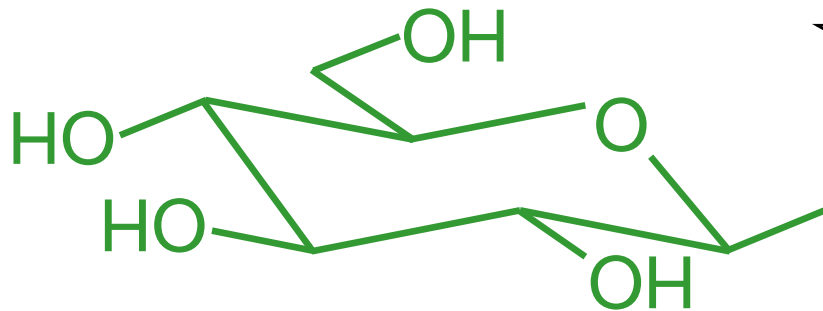
📖 Kümmerer (2007) Green Chem. 9, 899

Improving Lead Structure: Ifosfamide and Glufosfamide

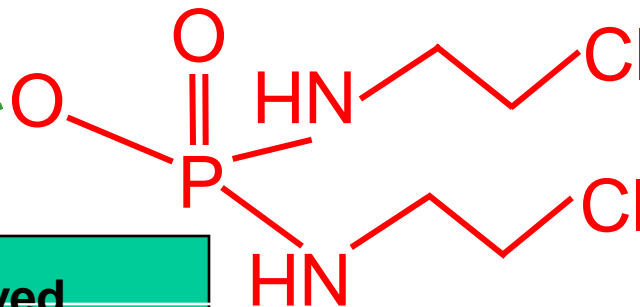
Ifosfamide:
not biodegradable (0%)





β -D-Glc-IPM („Glufosfamide“)



keeping the active moiety

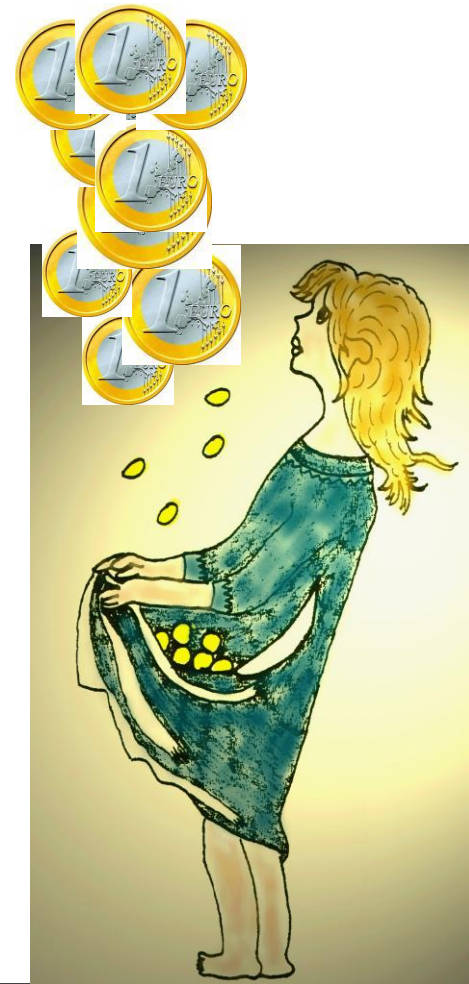


well biodegradable (> 70%), improved
resorption in the gut; clinical trial phase III

 Kümmerer et al. Chemosphere, 40, 767 (2000)
 <http://www.thresholdpharm.com/sec/glufosfamide>

Incentives

- ... within a generation chemicals should be produced and applied that do not have any impact on the environment. (EU Parliament and EU-Commission 2002)
- ... there will be an increase of innovation and economical advantages for healthy and environmental friendly products. (German Advisory Board for Environment 2003)
- Patent life time
- New business case



Sustainable Pharmacy: What next!

- **Setting up a research and education programme**
- **Creation and identification of success stories!**
- **Identification of opportunities and limitations
→ Road Map**
- **Role of education and dissemination of knowledge!**
- **Legislation**

Summary

Life Cycle
All stakeholders
Economical Aspects
Social Aspects
Cultural Aspects...