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INTRODUCTION TO THE STUDY OF PHARMACOLOGY

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Pharmacology, definition, aims

„pharmacon“ + „logos“ / „logia“

Scientific discipline dealing with
INTERACTIONS BETWEEN SUBSTANCES..
introduced into the organism from the environment

..AND THE LIVING ORGANISM
on all levels of complexity:
molecular
cellular
organ
organism as a whole

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DRUG

„substance or mixture of substances, suppopsed to be administered to the humans or animals for prevention, treatment or diagnosis of diseases or its symptomes or for physiological function adjustment“

Drugs are administered for

- Prevention,
- Diagnosis,
- Treatment of disseases

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Pharmacon/um – drug

classical WHO definition:
„Any substance (other than normal body components or substances necessary for normal body functions (food, water, oxygen), that, after administration into the organism evokes a change of a body function“

More precise definition according to Ph.Eur.:
Substances or their mixtures designed to the administration in humans or animals with a purpose of treatment, mitigation, prevention or diagnose of a disease or its symptoms and also to modulation of physiological substances.

European Pharmacopoea (Ph. Eur. 6th Ed.)
Pharmacopoea Bohemica 2009 (Ph. B. 2009)

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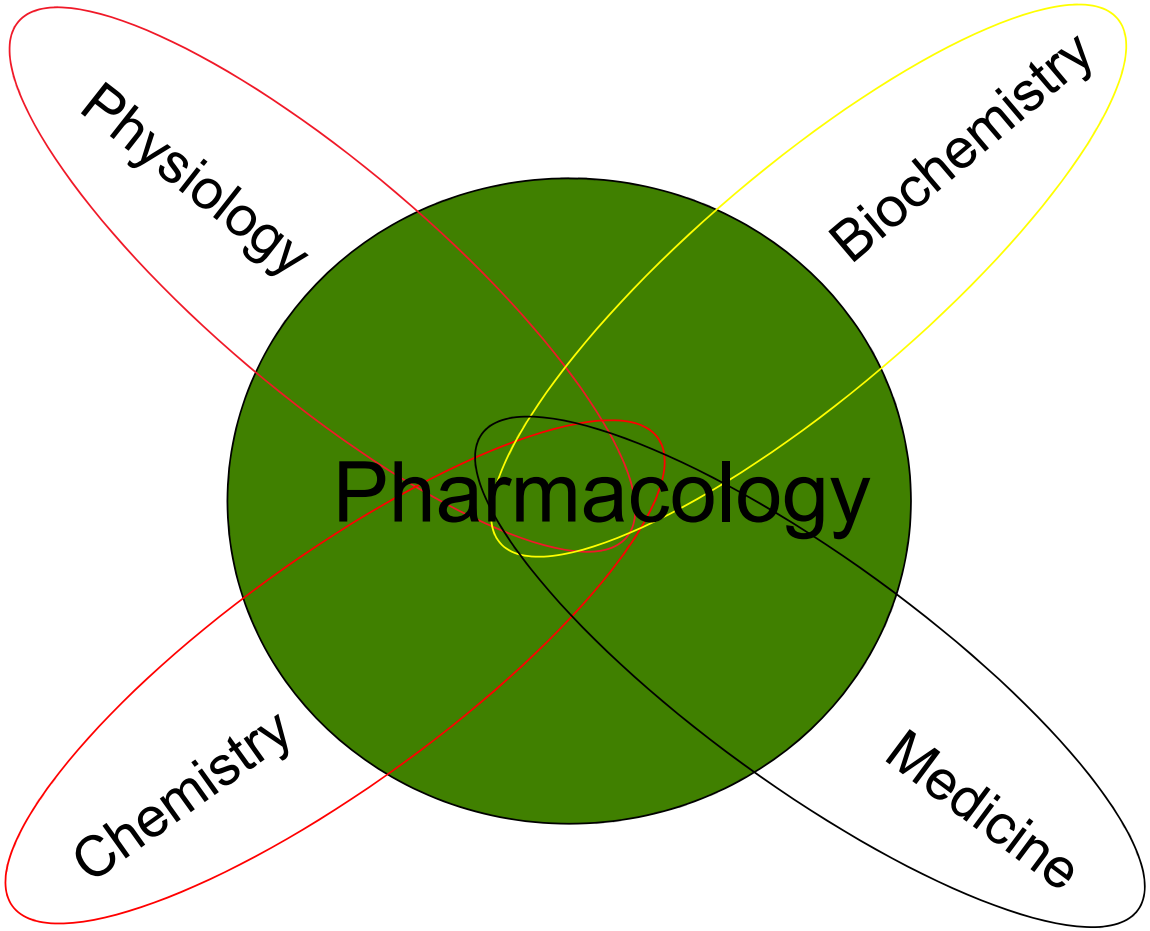
A synthesis of several biomedical sciences….



…but unique in its own right

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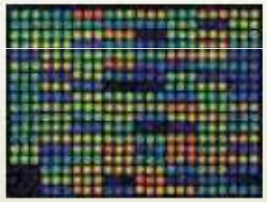
Pharmacologists study science at <u>every</u> level

Genetic

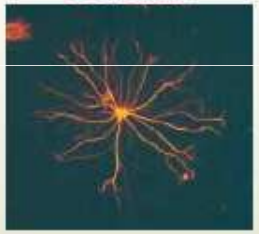


Gene Chip Microarray.
Courtesy of Annette Thelen, MSU Genomics Structure Facility.

Molecular

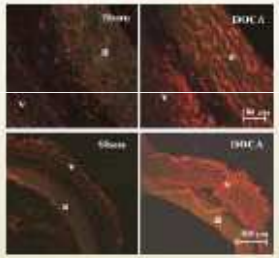
Interaction of the dopamine (D2) and dynorphin system in regulation of tuberoinfundibular neuronal function.
Courtesy of Y. Will-Murphy and K. Lookingland

Cellular



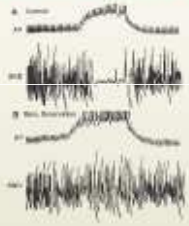
Astrocyte, labelled with Glial Fibrillary Acidic Protein
Courtesy of J. Edwards and B. Atchison.

Tissue



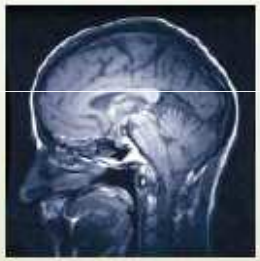
Superoxide measurement through dihydroethidium in artery (a) and vein (v) of normotensive (sham) and hypertensive (DOCA) rats.
Courtesy of H. Xu and J. Galligan

Whole Animal



Effect of sectioning baroreceptor nerves (denervation) on the inhibition of sympathetic nerve discharge during a rise in arterial pressure in an anesthetized cat.
AP = arterial pressure, SND = sympathetic nerve discharge.
Courtesy of S. Barman and G. Gebber.

Human



MRI of Human Head
Courtesy of Kevin Henley and James Patchen of the Radiology Department, MSU

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What Pharmacology is NOT...

❖ Pharmacy

This is a separate profession responsible for the preparation and dispensation of medication.

❖ Pharmaceutical Science

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Basic Pharmacology

General principles

Systems Pharmacology

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General principles

Principles which predestinate the interactions of the drug and body

Two important and interrelated areas:

- General Pharmacokinetics

- General Pharmacodynamics

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Pharmacokinetics (PK)

Deals with the fate of the drug in the body – processes of

Absorption,
Distribution
Metabolism
Excretion

„What the body makes with the drug“

…“ADME“

Pharmacodynamics (PD)

deals with the mechanism of action (e.g. receptor sites, molecular level of action..)

„How does it work“

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Systems Pharmacology

Is focused on individual organ systems and its pharmacotherapy

e.g.
Autonomic drugs
Psychoactive drugs
Drugs used in cardiovascular diseases….

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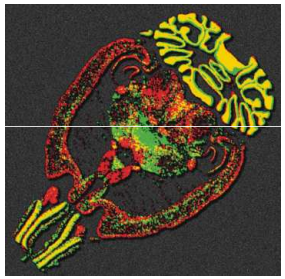
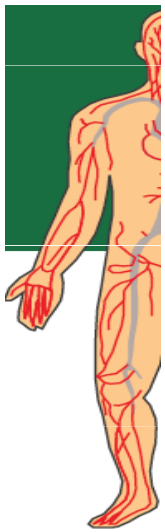
Systems Pharmacology

❖ **Neuropharmacology:** study of the effect of drugs on components of the nervous system (brain, spinal cord, nerves)



Example: treatment of Alzheimer‘s disease

❖ **Cardiovascular Pharmacology:** study of the effects of drugs on heart, vasculature, kidney, nervous and endocrine systems that participate in cardiovascular function.



Example: treatment of high blood pressure (hypertension)

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Branches of Pharmacology

Clinical pharmacology

- deals with different drugs and their varied clinical usage

- interdisciplinary branch, which integrates basic and experimental Pharmacology with the clinical and complementary branches

AIM: to study and evaluate the effect of the drug using objective methods (EBM)

Sub-branches of clinical pharmacology:
Clinical Pharmacokinetics, clin. Pharmacodynamics, Rational prescribing, Clinical toxicology

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Toxicology

the study of the toxic effects of chemicals on living organisms

study of symptoms, mechanisms, treatments and detection of poisoning

experimental (in vitro, in vivo)

clinical - poisoning prophylaxis, diagnosis, treatment

forensic toxicology…

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Pharmacogenetics

deals with the influence of genetic variation on Pharmacokinetics and Pharmacodynamics

study of the drug response in patients by correlating gene expression or single-nucleotide polymorphisms with a drug's efficacy or toxicity

consequences can be either quantitative or qualitative

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Pharmacogenetics

1959 Friedrich Vogel used first time term „pharmacogenetics“

1997 First time used term “**Pharmacogenomics“**

Pharmacogenetics considers one or at most a few genes of interest, while pharmacogenomics considers the entire genome.

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Biochemical and molecular pharmacology

detail study of the mechanism of action at molecular level

Chronopharmacology

Study of the action of the drugs with respect to the biorhythm

(antiasthmatics, glukocorticoids, statins, etc.)

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Pharmacoepidemiology

- study of the effect of drugs on populations; questions dealing with the influence of genetics are particularly important

risks and benefits of the therapy using epidemiological methods

Approach of the health specialists (GP, pharmacist)

patient (compliance)

society (drug abuse, marketing, financial resources…)

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Pharmacoeconomy

- rationalize the use of sources in health care

- Compares the costs of therapeutic approaches by the pharmacoeconomical analyses

The goal is not „to decrease total money spent in health care“ , but to use the sources effectively

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Pharmacovigilance

Pharmacological science relating to the detection, assessment, understanding and prevention of adverse effects

collecting, monitoring, researching and evaluating information from healthcare providers and patients on the adverse effects of medication

Drug safety monitoring

AIM: to minimize the risk of adverse effects

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Experimental pharmacology

Biological experiment

in vitro – isolated structures or organs,

cell cultures, microorganisms

- regulatory factors we have to satisfy:

☺ ethical (replacement, refinement, reduction)

☺ small amounts of drugs

☺ use of human cells

☹ elimination of systhemic reaction of the whole body

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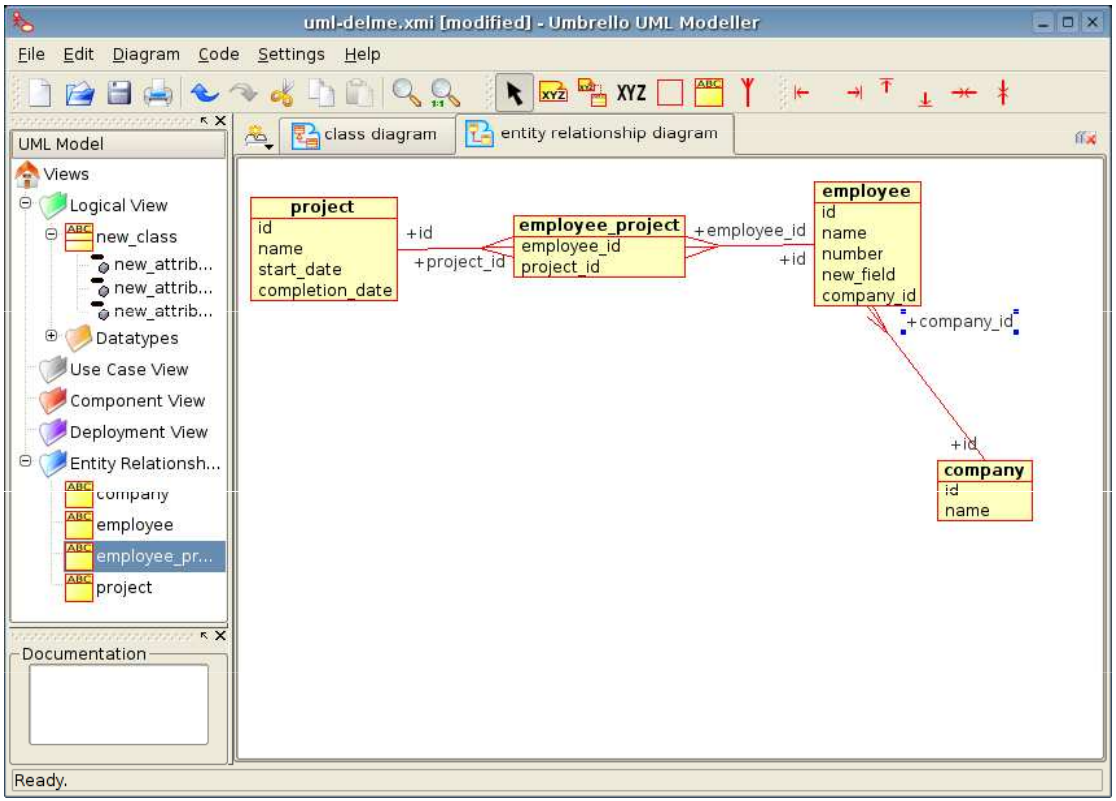
Biological experiment

in silico – use of IT, especially computer modelling (f-kinetics), databases



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Biological experiment

in vivo – whole animal

- systhemic effects

- we record toxicity, possible adverse and alergic effects

- impact on memory and other cognitive faculties, learning abilities, depression

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Experimental animal

Experimental animal (is born, breed and maintained for experimental purposes)

Defined genetic features:

- **randombred** – natural breeding - heterozygots
- **inbred** – breeding of brosthers and sisters, approx. 20 generations

  homozygots

  diabetic mice, hypercholesterolemic mice, hypertonic mice…

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Experimental animal

Defined microbial settlement:

- **SPF** – have 4-5 saprofyte patogens
- **Gnotobiotic animals** – are born by hysterectomy, pathogens free
- **Conventional breeding** – not defined settlement

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Experimental animal

Mammals

RODENTS: mouse, hamster, rat, guinea-pig

NON-RODENTS (e.g. Lagomorpha): rabbit

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Experimental animal

Mammals

carnivores: dog, cat, ferret

Mammals

monkeys: macaque (Macacus sp.), green monkey (*Erythrocebus* sp.)

Birds

common quail, hen, duck

Amphibians

Xenopus sp.

Fish

guppy (Poecilia reticulata), carp, trout

Crustaceans

Cladocera, Cyclops strenuus

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Laws

EU

1986 Council of Europe – rules of protection for vertebrates used for experimental purposes in Europe

Principle 3R: replacement

reduction

refinement

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Laws

Czech Republic

Law no. 149/2004 „*na ochranu zvířat proti týrání*“ – about animal protection against cruelty

Notice no. 207/2004 „*o ochraně, chovu a využití pokusných zvířat*“ - about protection, breeding and use of laboratory animals

Authorities encharged of animal protection:

Ministry of agriculture, Comission for animal protection, veterinary authorities, ethical comitties

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Drug names

Chemical name
according to the IUPAC nomenclature rules
e.g.: N-acetyl-para aminophenol

Generic name (non-proprietary)
INN (International Non-proprietary Name)
not registered, supposed to be used internationally
has to be printed on the packing of the drug (under the registered trade name)
for the universal terminological identification of the medicines
formed from the chemical name (shortness) accordingly with the rules (WHO)
each drug has its own CAS No (Chemical Abstracts Sevice Number)

e.g. paracetamol

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Drug names

Trade name (proprietary)

registered, patent-protected ®
has to be acompanied with the INN
e.g. Panadol, Coldrex, Paralen

Officinal name

latin name in Pharmacopoeia (e.g. Paracetamolum)
usually very similar to INN
has to be prescribed on Rx formulary in case of individually prescribed medicines
established name for a drug substance is usually found in the originating country's Pharmacopeia
Paracetamolum
...

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Some drug-family names

-olol	betareceptor antagonists
-caine	local anaestethics
-tidine	histamine receptor antagonists
-dipine	calcium channel blockers of dihydropyridine type
-statin	inhibitors of HMG CoA transferase

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DOSE

A specified quantity of a therapeutic agent, prescribed to be taken at one time or at stated intervals.

If administered in the body, desintegrates, solutes, and distribute across the barriers in the body compartments. Than it is measured like „concentration“

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DOSE

DOSIS SINGULA - single dose

on Rx !

DOSIS PRO DIE - daily dose

- for 24 h !!

DOSIS CHRONICA

- (adjusted) dose in the chronic treatment (long-term)

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DOSE

DOSIS CURATIVA

- total dose of the drug needed for whole period of treatment

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DOSE (from effect point of view)

Sub-threshold - cause no observed biological effect

Threshold - minimally effective dose; dose, after which can be observed any effect

Therapeutic dose - produces mostly beneficial effects;

► MAXIMAL
- does not produce harmfull effects

►► DOSIS MAXIMA SINGULA
►► DOSIS MAXIMA PRO DIE

TOXIC – mostly harmfull effects (RISK>BENEFIT)

LETHAL – cause death

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ORIGIN OF DRUGS

- Modification of the chemical structure of the already known drug
- Searching for natural substances
- Investigation (screening) of already known chemical compounds
- Targeted synthesis of substances with a structure designed by computer modeling

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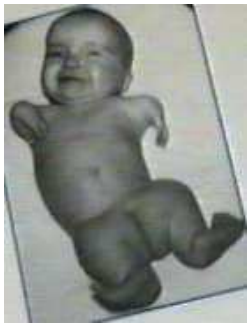
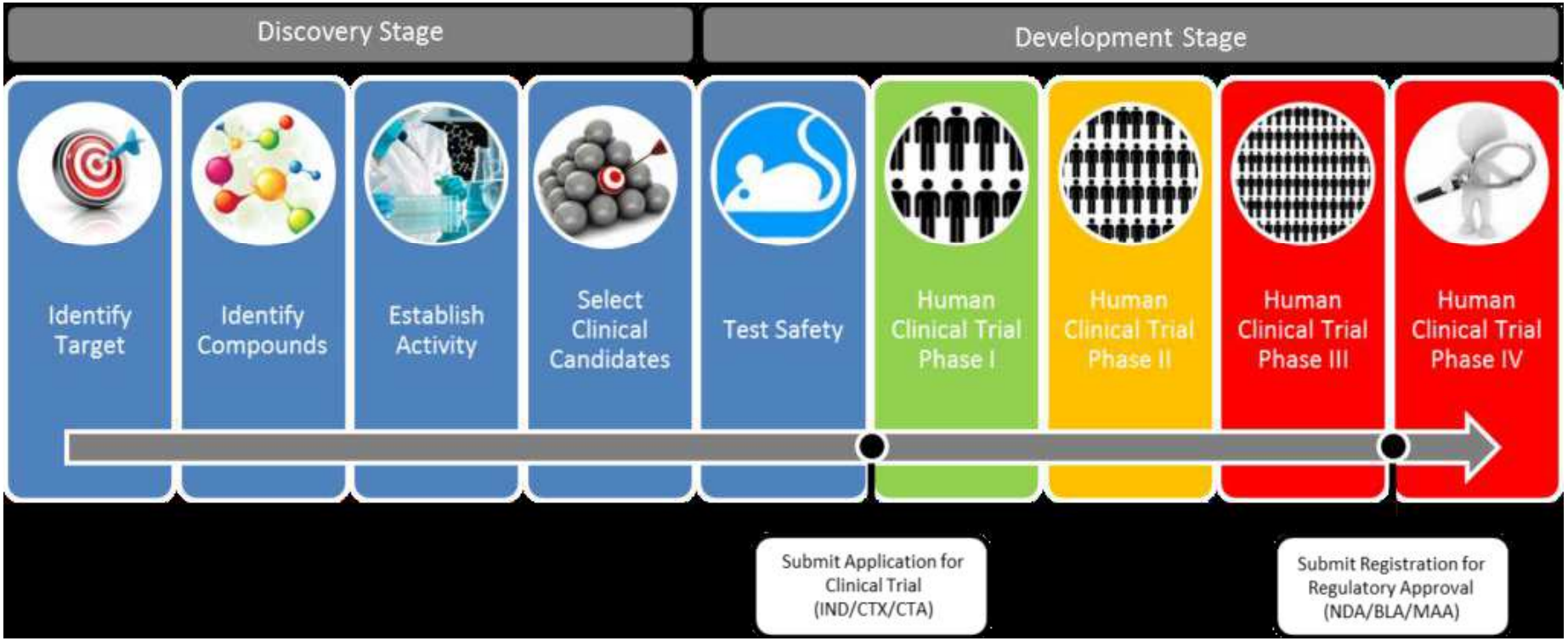
Origin of drugs – synthesis/isolation

Medicinal Plants (cardiac glycosides)
Animal tissues (heparin)
Microorganisms (penicillin)
Human cells (autologue vaccines)
Biotechnology (insulin, MAb)

Thalidomide crisis

Thalidomide - Contergan ©
1950 - 1960
hypnosedative used by pregnant women
It gave birth to 12,000 children with disabilities




Discovery Stage
Development Stage
Identify Target
Identify Compounds
Establish Activity
Select Clinical Candidates
Test Safety
Human Clinical Trial Phase I
Human Clinical Trial Phase II
Human Clinical Trial Phase III
Human Clinical Trial Phase IV
Submit Application for Clinical Trial (IND/CTX/CTA)
Submit Registration for Regulatory Approval (NDA/BLA/MAA)

PRECLINICAL TRIALS :

- Evaluation of effect in vitro
- Evaluation of effect + toxicity in animal models (2 animal species at least)

In situ

- Influencing organ systems that can not be studied in isolation (e.g. CVS , GIT)

Living animals

- overall effects (convulsions , sedation , anesthesia, temperature)
- affecting cognitive function (learning, attention, memory)
- influence on the specialized function (immune system)

.

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Preclinical Trials:

- Evaluation of acute and short term toxicity in animals. It Involves :
  - -Lethal dose determination
  - -Effect of dose at normal level for short/Long term
- Assess how the drug is absorbed/distributed/metabolized and excreted in animals.

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Phase 1 CLINICAL TRIALS :

- All CTs has to be approved by SUKL

  (State institute for drug control)/EMA
- Drug given to 10-100 healthy volunteers
  - Duration could vary from 1 month to 1 year.
- Following is studied here :
  - Drug absorption/Metabolism in human.
  - Effect on organs and tissues
  - Side affect of different dosages.

Proceed to next Stage

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Phase 2 CLINICAL TRIALS :

- 1 st administration to the patient
- randomized clinical trial tested the drug x = standard therapy x placebo
  - Often called „Blinding“ – blinding also in multicentric manner
- It monitors the effect of the disease, dose , pharmacokinetics in patients
- Informed consent , with no financial reward

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Phase 2 CLINICAL TRIALS :

- Drug given to 100 - 300 patients - volunteers
- Duration could vary from 1 year to 2 years
  - Cost could vary from $10 - $100 million.
  - Following is studied :

    Drug effectiveness in treating the disease.

    acute side effects in patients

    Less than 1/3rd of New Chemical Entities (NCE) enter phase 2

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Phase 3 CLINICAL TRIALS :

- Phase 3 - Extended trial
- Patients 100-1000
- Comparison of the therapeutic efficacy and safety to standard therapy
- In the Czech Republic a year to 300 proposals involving 30,000 patients
- Coordinates the SUKL/EMA/FDA
- Approval for new substances to launch the market issued by the State Institute for Drug Control (SUKL)/EMA (European Medicines Agency)

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Phase 3 CLINICAL TRIALS :

- FDA consulted before beginning phase 3
  - Drug given to 1000-3000 patient volunteers
  - Duration could vary from 3 years to 4 years.
  - Cost could vary from $10 - $500 million
- Following is studied here :
  - Safety of Drug [Benefits v/s risk analysis] –
  - Long term side effects in patients
- Proceed to next Stage - registration

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Market Launch/Phase 4 :

- 4th phase - post-registration
- post-marketing evaluation
- verification of effects in broad clinical practice
- An average of 5 years
- Data on the incidence of adverse effects, interactions , differences in the age groups etc.
- Comparison with standard therapy
- The possibility of drug withrawal

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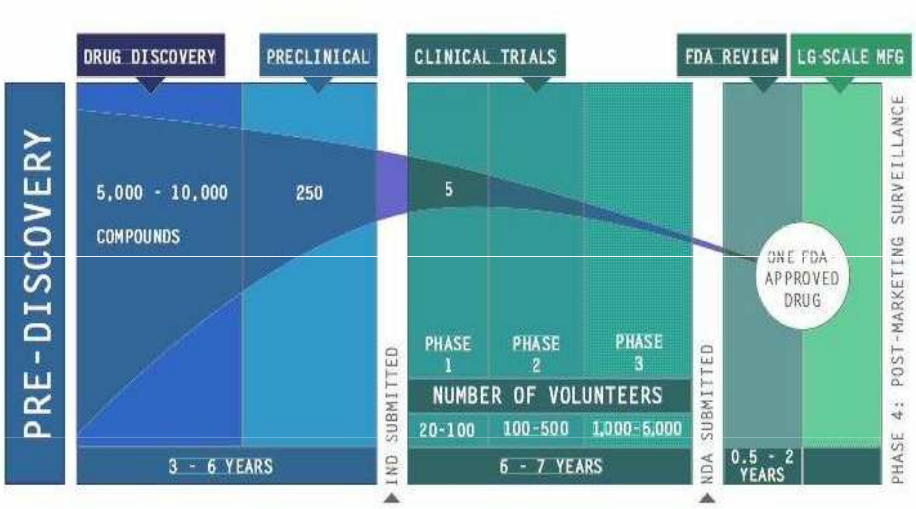
Market Launch/Phase 4 :

- Additional post marketing testing of patients to
  - Support the use of the approved indication
  - Finding new therapeutic opportunities
  - Extending use of the drug to different classes of patients like children



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Examples of drug withdrawals

rofecoxib (HVLP Vioxx)

CVS AE, - AMI

clobutinol (HVLP *Silomat*)

Heart dysrhytmias

rosiglitazon

CVS risk

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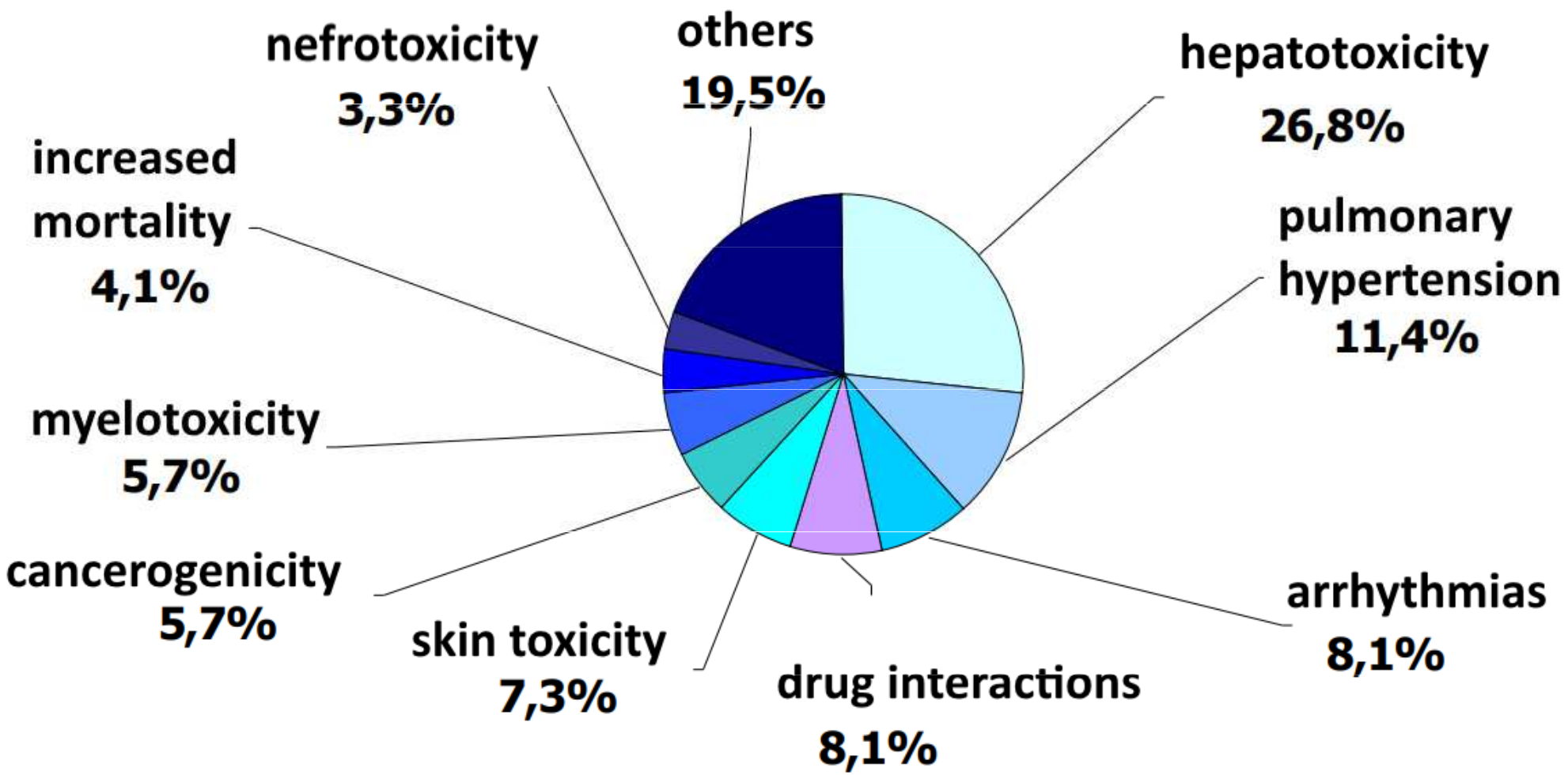
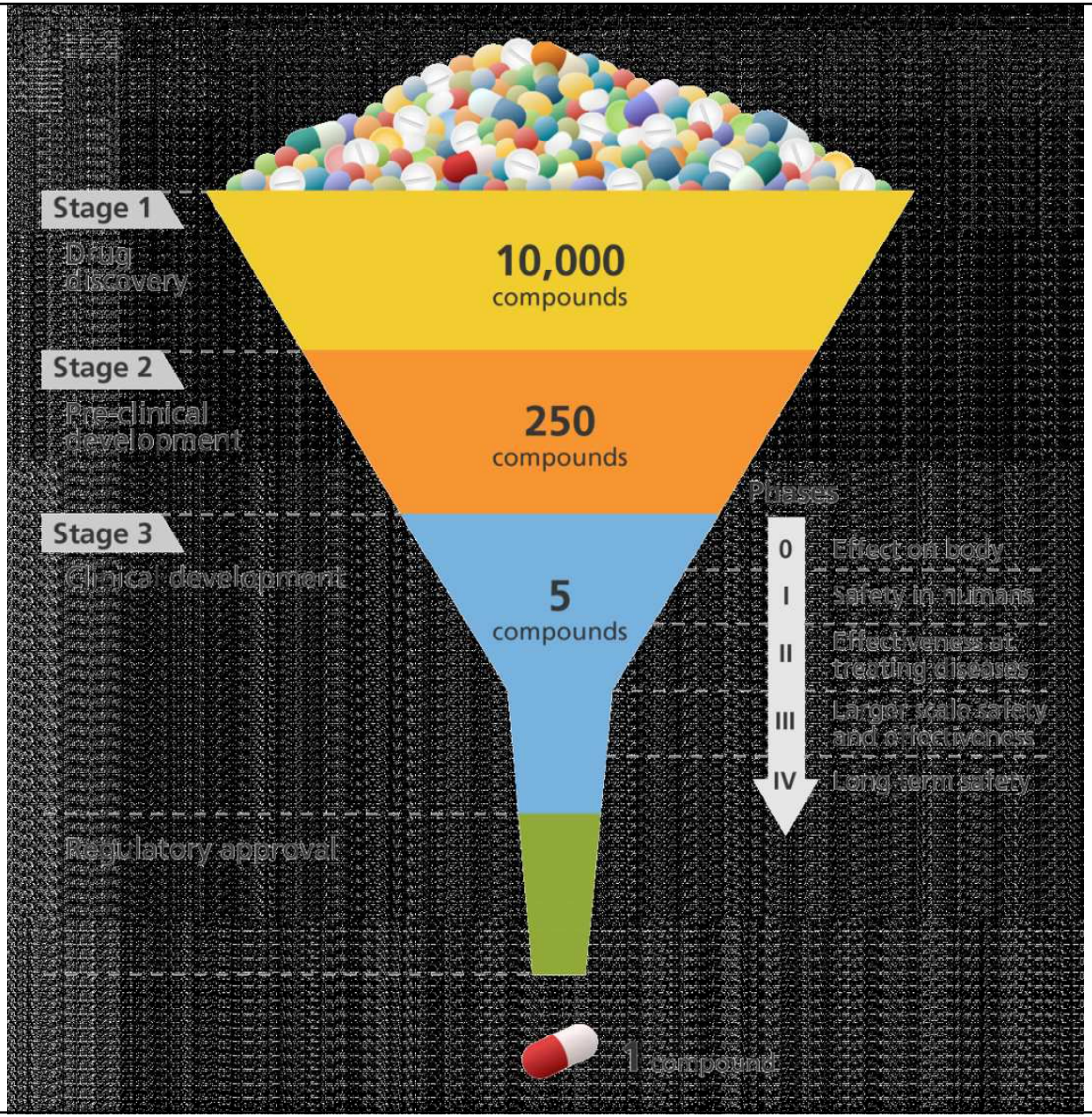
Reasons for drug withdrawal




Stage 1
Drug discovery
10,000 compounds
Stage 2
Pre-clinical development
250 compounds
Stage 3
Clinical development
5 compounds
Regulatory approval
1 compound
Phases
0
I
II
III
IV
Effect on body
Safety in humans
Effectiveness at treating diseases
Larger scale safety and effectiveness
Long term safety

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