

Introduction to Drug Research



Until today
we met the terms:
„Drug Discovery“
and
„Drug Development“
in previous lectures.

Discovering and bringing
one new drug to the market
typically takes
an average of 14 years
of research
and clinical development
efforts.

We used them
for the first time
in the lecture concerned

The Drug Rendering System

For the second time
in the lecture concerned
the Pharmacy Profession

„Pharmacy“

is a **health profession** concerned with:

- discovery,
 - development,
 - production,
 - distribution,
 - dispensing
- 
- of drugs

Let's distinguish between

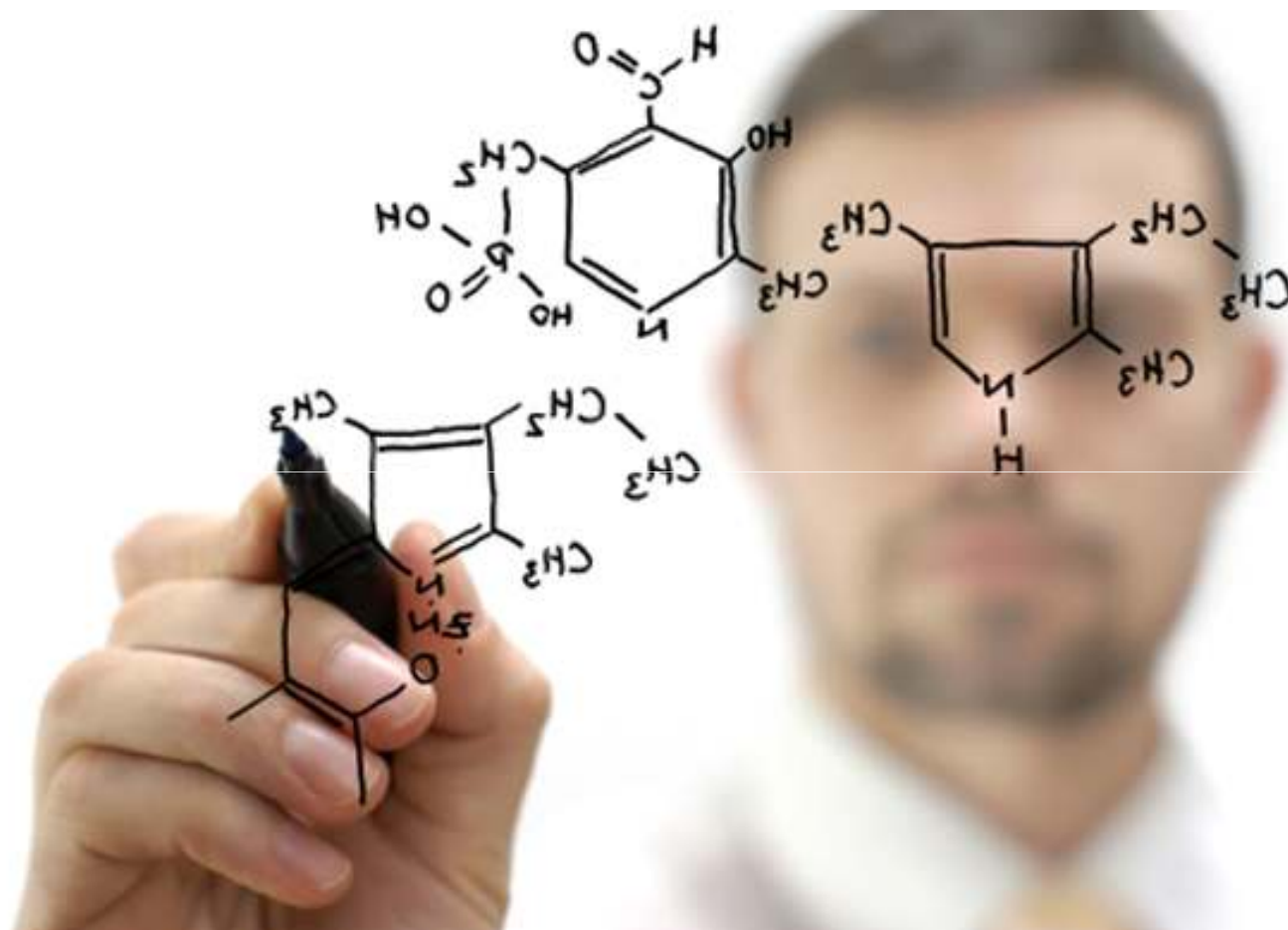
Drug Discovery

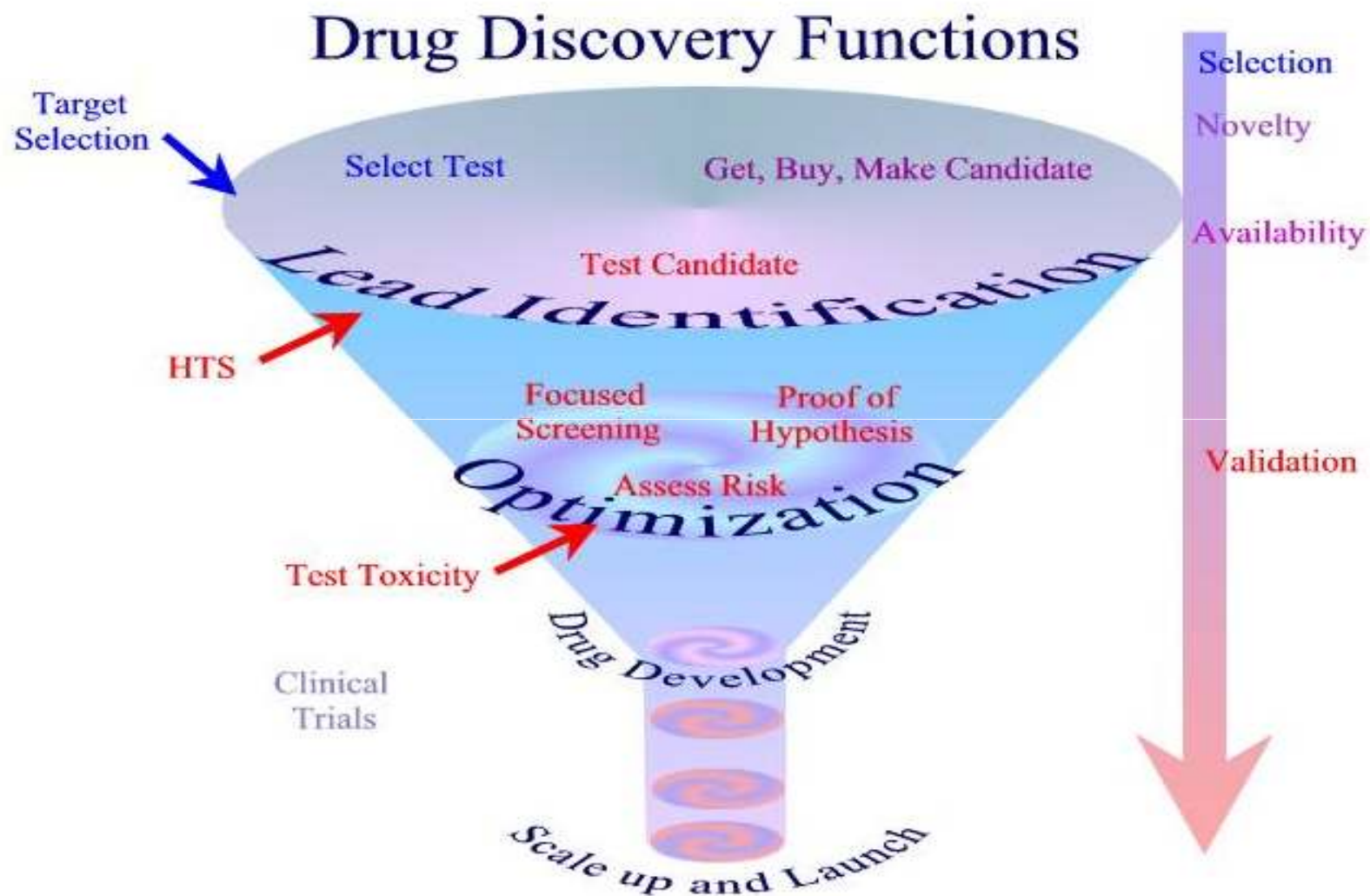
and

Drug Development

In pharmacy and medicine,
drug discovery is the process

by which drugs are
discovered and/or
designed.





Drug Discovery and Development from the viewpoint of the History

We brought a brief description of
the history of drug development
since the ancient times.

Drug Discovery and Development:

1. Early History of Pharmacy
2. Drug Discovery and Development in the Middle Ages
3. Foundation of Current Drug Discovery and Development
4. Beginnings of Modern Pharmaceutical Industry
5. Evolution of Drug Products

Drug **discovery and development**
has a long history and dates back to the
early days of human civilization.

In those ancient times, drugs were not just
used for physical remedies but were also
associated with religious and
spiritual healing.

Sages or religious leaders were often the
administrators of drugs.

The early drugs or folk medicines

were mainly derived from plant products, and supplemented by animal materials and minerals.

These drugs were most probably discovered through a combination of trial and error

experimentation and observation of human and animal reactions as a result of ingesting such products.

Although these folk medicines probably
originated independently in
different civilisations,

there are a number of similarities,
for example, in the use of same herbs for
treating similar diseases.

This is likely to be a contribution by ancient
traders, who in their travels might have
assisted the
spread of medical knowledge.

Folk medicines were the only available treatments until recent times.

Drug discovery and development started- to follow scientific techniques in the late 1800s.

From then on, more and more drugs were discovered, tested and synthesized in large-scale manufacturing plants, as opposed to the extraction of drug products from natural sources in relatively small batch quantities.

Although pharmaceutical drugs are now widely
used worldwide,

many ethnic cultures have retained their
own folk medicines.

In certain instances,
these folk medicines exist side by side and
are complemented by pharmaceutical
drugs.

The following are some snapshot examples
of how drugs were discovered from the
early human civilisations.

Chinese medicine

Traditional Chinese medicine (TCM) is believed to have originated in the times of the legendary emperor Sheng Nong in 3500 BC.

The dynasty system and meticulous recording have helped to preserve the TCM scripts of old China. Some important medical writings are *Shang Hun Lun* (Discussion of Fevers), *Huang **Di** Nei Jing* (The Internal Book of Emperor Huang) and *Sheng Nong Ben Cao Jing* (The Pharmacopoeia of Sheng Nong-a legendary emperor).

Egyptian medicine

Ancient papyrus provided written records of early Egyptian medical knowledge. The Ebers papyrus (from around 3000 BC) provided 877 prescriptions and recipes for internal medicine, eye and skin problems, and gynecology.

Medications were based mainly on herbal products.

Indian medicine

The Indian folk medicine, can be traced back
3000-5000 years,
and was practiced by the Brahmin sages of
ancient times.

The treatments were set out in sacred writings
called Vedas. The materia medica are extensive
and most are based on herbal formulations.

Some of the herbs have
appeared in Western
medicines.

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Greek medicine

Some of the Greek medical ideas were derived from the Egyptians, Babylonians, and even the Chinese and Indians.

The greatest Greek contribution to the medical field is perhaps to dispel the notion that diseases are due to supernatural causes or spells.

The Greeks established that diseases result from natural causes. Hippocrates, the father of medicine, at about 400 BC is credited with laying down the ethics for physicians.

Greek Medicine

Some examples:

Castor oil was prescribed as a laxative;
linseed or flax seed were used as a soothing
emollient, laxative and antitussive.

Other treatments include fennel plant for
relief of intestinal colic and gas, and
asafoetida gum resin as an antispasmodic.

Asclepius: Greek God of Medicine

In Greek mythology, Asclepius, the god of medicine, studied medicine under Chiron. He excelled over Chiron, and his medical skills were reputed to be able to bring back the dead. This incurred the wrath of Pluto, the god of the underworld, and the envy of other gods. They complained to Zeus, who also thought that he alone should have the power of life and death. Zeus slew Asclepius with a thunderbolt. However, Asclepius' daughters, Panacea and Hygeia, survived and carried on to tend to the sick.

Roman medicine

As great administrators,
the Romans instituted hospitals,
although these
were used mainly to cater for the needs of
the military.

Through this work,
organized medical care was made
available.

Roman medicine

The Romans also extended the pharmacy practice of the Greeks.

Dioscorides and Galen were two noted physicians in Roman days.

Dioscorides' *Materia Medica* contains descriptions of treatments based on 80% plant, 10% animal and 10% mineral products.

DRUG DISCOVERY AND DEVELOPMENT **IN THE MIDDLE AGES**

The Middle Ages,
from around **AD** 400 to 1500,
witnessed the decline of the Roman influences.
This was also the time when plagues scourged
many parts of Europe. Diseases such as bubonic
plague, leprosy, smallpox, tuberculosis and
scabies were rampant.
Many millions of people succumbed to these
diseases.

The early Church

There are some references to herbs in the Bible.

However, the Church's **main contribution to medicines is the preservation and transcription of Greek medical manuscripts and treatises.**

This enabled the knowledge developed in the ancient times to be continued and later used in the Renaissance period.

Arabian medicine

Through trades with many regions, the Arabians learned and extended medical knowledge.

Their major contribution is perhaps the knowledge of medical preparations and distillation methods, although the techniques were probably derived from the practices of alchemists.

Avicenna, around AD 900-1000, recorded a vast encyclopedia of medical description and treatment.

Another noted physician was Rhazes, who accurately described measles and smallpox.

FOUNDATION OF **CURRENT** DRUG DISCOVERY AND DEVELOPMENT

The Renaissance period laid the foundation for scientific thoughts in medicinal preparations and medical treatments.

There were many advances made in anatomy, physiology, surgery and medical treatments, including public health care, hygiene and sanitation.

BEGINNINGS OF MODERN PHARMACEUTICAL INDUSTRY

Despite the advances made in the 1800s, there were only a few drugs available for treating diseases at the beginning of the 1900s. These were:

- Digitalis: extracted from a plant called foxglove, digitalis stimulates the cardiac muscles, and was used to treat cardiac conditions
- Quinine: derived from the bark of the Cinchona tree, and used to treat malaria
- Ipecacuanha: extracted from the bark or root of the Cephaelis plant,
and used to treat dysentery
- Acetylsalicylic acid: extracted from bark of willow tree, and used for the treatment of fever
- Mercury: used to treat syphilis.

More systematic research was being performed to
discover new drugs from the early 1900s.

EVOLUTION OF DRUG PRODUCTS

In the early days, until the late 1800s, most drugs were based on herbs or

extraction of ingredients from botanical sources.

The synthetic drugs using chemical methods were heralded at the beginning of the 1900s, and the pharmaceutical industry was founded.

Many drugs were researched and manufactured, but mostly they were used for

therapeutic purposes rather than completely curing the diseases.

EVOLUTION OF DRUG PRODUCTS

From the early 1930s, drug discovery concentrated on screening natural products and isolating the active ingredients for treating diseases.

The active ingredients are normally the synthetic version of the natural products.

These synthetic versions, called new chemical entities (NCEs) have to go through

many iterations and tests to ensure they are safe, potent and effective.

There are 4 basic items:

An Overview of the Drug Discovery
and Development Process

The Pharmaceutical Industry

Economics of Drug Discovery and
Development

Trends in Drug Discovery and
Development

An Overview of the Drug Discovery and Development Process

Although human civilization has been experimenting and consuming drugs for many centuries, it is only in the past 100 years that the foundation was laid for the systematic research and development of drugs.

Teams

of pharmacists, scientists, clinicians, and statisticians, as well as marketing, pharmaceutical and medical practitioners, and even economists and legal attorneys,

are involved in the
process of drug
discovery and
development.

After World War I,
the modern pharmaceutical
industry
came into being,
and drug discovery and
development following
scientific principles was
firmly established.

Previously,

the main scientific personnel in the discovery process have been the synthetic chemists.

Nowadays

molecular biologists, biochemists, microbiologists
and even computer scientists play equally
important roles
in the drug discovery and development processes.

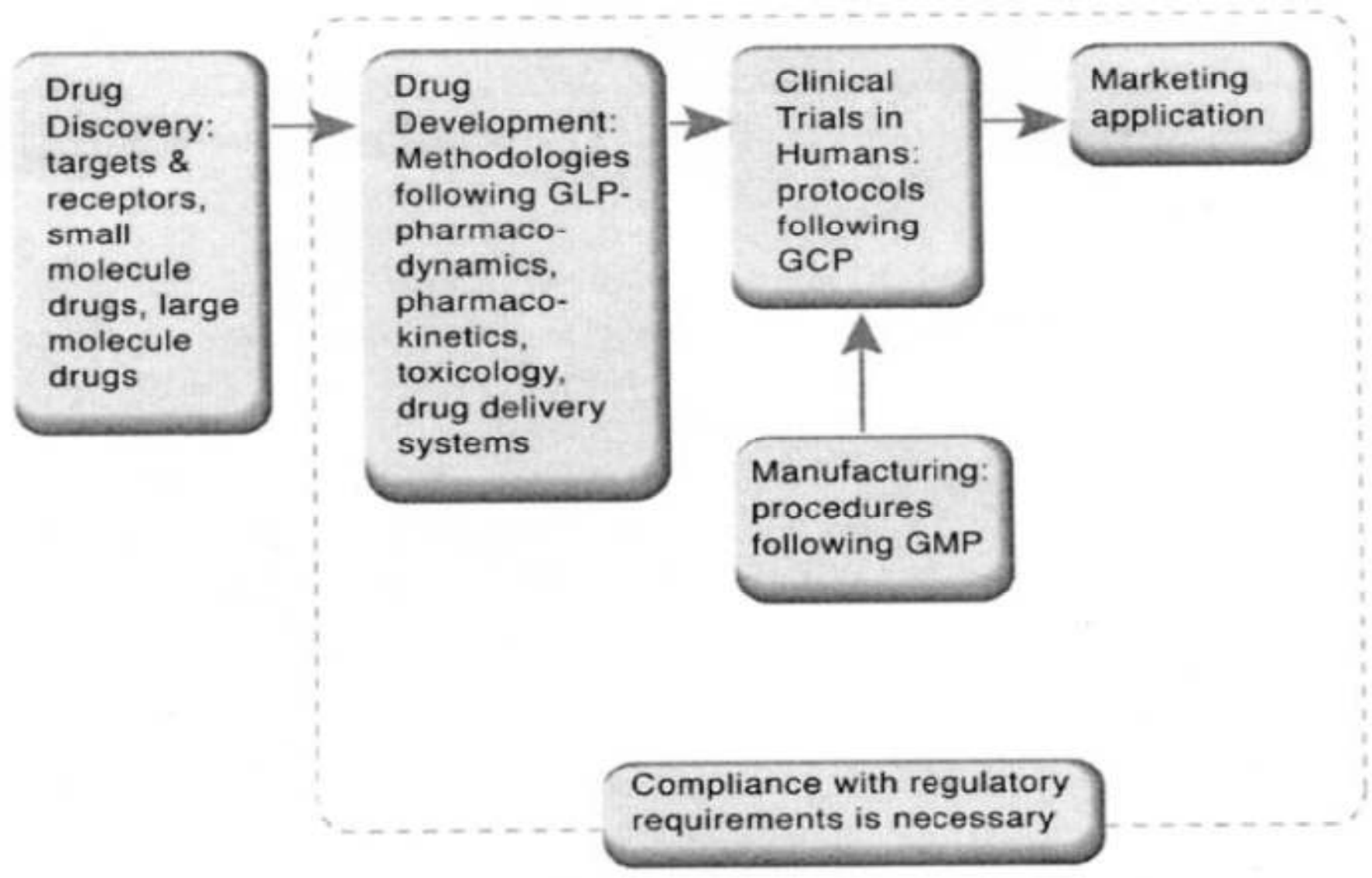
The reason for this
is that drug discovery and
development has made a
quantum leap forward in the
past decade with progress in
genomics and biotechnology.

It is estimated that,
on average, a drug takes 10-12 years from
initial research to reach the
commercialisation stage.

The cost of this process is estimated to be
more than US\$ 500 million.

From discovery to marketing approval of a
drug, the following stages are involved
(see next Figure)

An Overview of the Drug Discovery and Development Process



Drug Discovery

The process involves finding out the target that causes the disease.

Next, chemical or biological compounds are screened and tested against these targets or assays, which are representative of these targets, to find leading drug candidates for further development.

Drug Discovery

Many new scientific approaches are now used to determine targets (most targets are receptors or enzymes) and obtain the lead compounds; including the use of genomic technology, synthetic chemistry, recombinant DNA (rDNA) technology, laboratory automation and bioinformatics.

Drug Development:

Tests are performed on the lead compounds in test tubes (laboratory, in vitro) and on animals (in vivo) to check how they affect the biological systems.

The tests, often called preclinical research activities, include toxicology, pharmacodynamics and pharmacokinetics, as well as optimization of drug delivery systems.

Many iterations are carried out,

and the leading compounds are
modified and synthesized

to improve their

interactions with the targets, or to

reduce the toxicity or improve
pharmacokinetics performance.

At the end of this process,

an optimized compound is found

and this becomes a potential drug
ready for clinical trial in humans.

The development work has to follow
Good Laboratory Practice (GLP) to
ensure that proper quality system
and ethical considerations are
established.

Only compounds that satisfy
certain performance and safety
criteria will proceed to the
next stage of clinical trial.

Clinical Trials

These are trials conducted
on human subjects.

Clinical trials

The pertinent parameters for clinical trials are protocols (methods about how trials are to be conducted), safety and respect for human subjects, responsibilities of investigator, institutional review board, informed consent, trial monitoring and adverse event reporting.

Clinical trials

have to follow regulations and guidelines from the FDA, the European Agency for the Evaluation of Medicinal Products (EMA) of the European Union (EU) or European Member States, Japan's Ministry of Health, Labor and Welfare (MHLW), or regulatory authorities in other prospective countries where the drug is intended to be registered and commercialised.

Clinical trials

are conducted in
accordance with
Good Clinical
Practice (GCP).

DRUG DEVELOPMENT

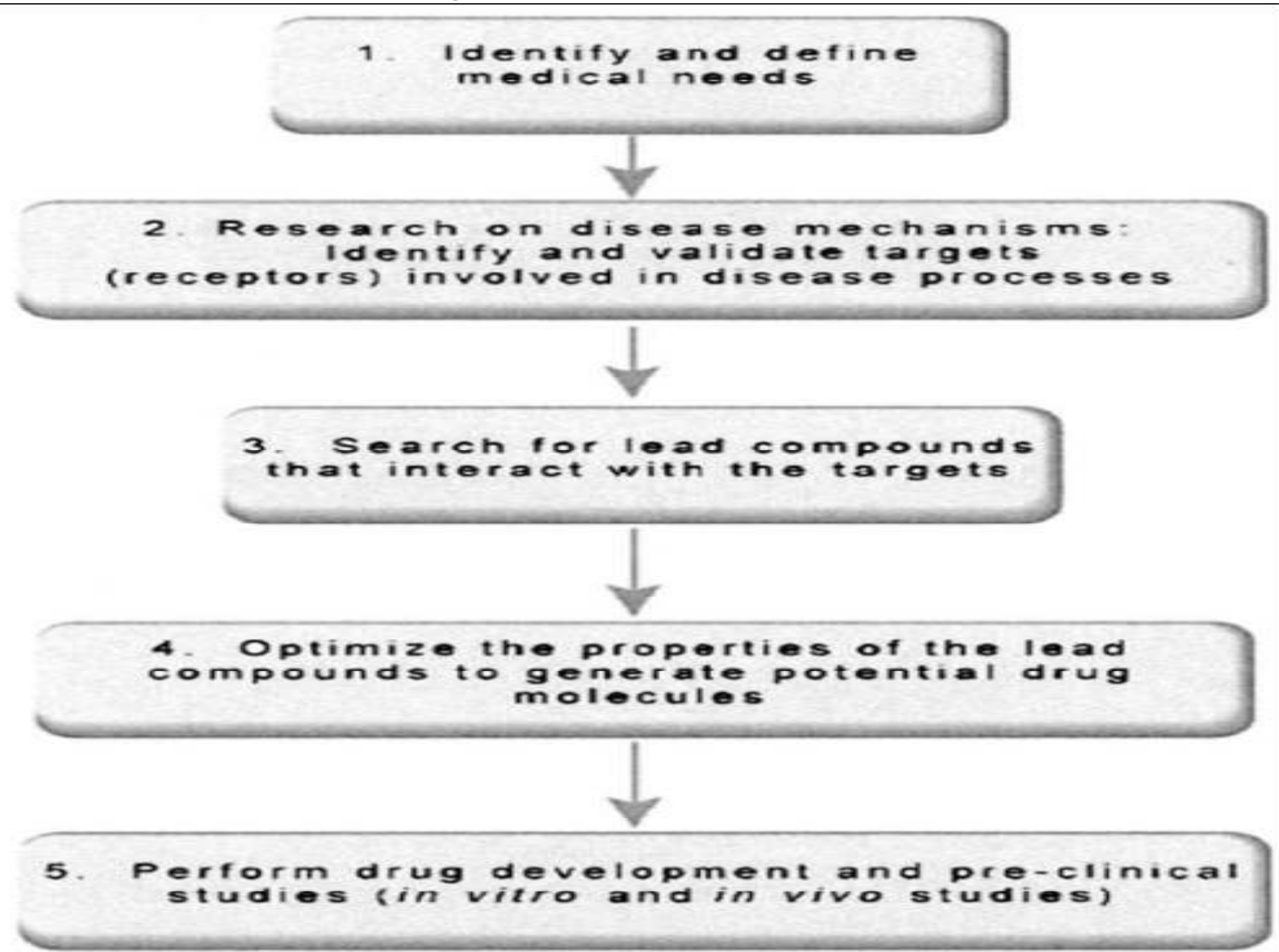


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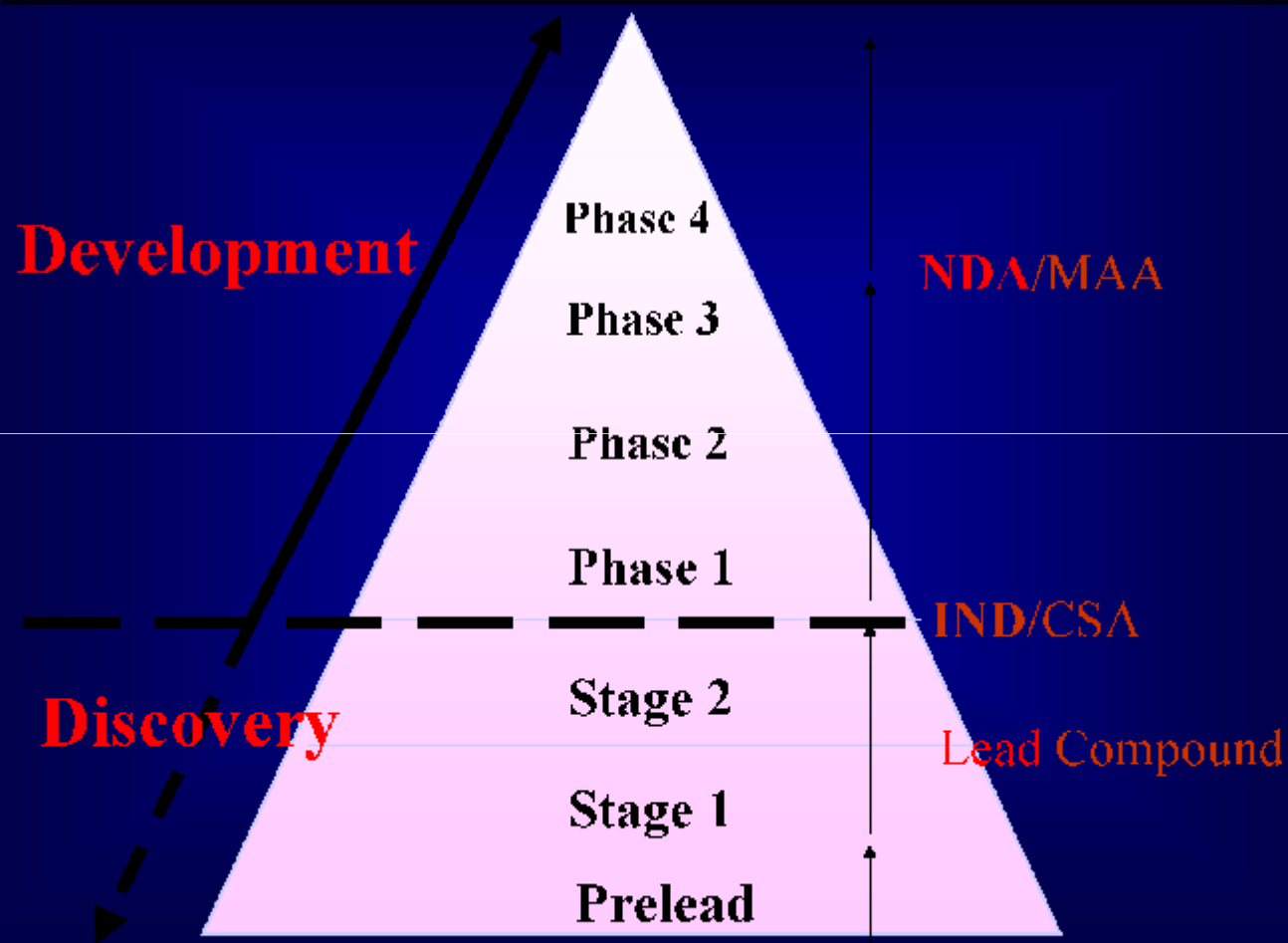
Drug discovery and development

are mainly carried out
by pharmaceutical companies,
universities and government
research agencies, although there
are increasing activities in the start-
up and smaller companies that
specialize in particular fields of
research.

Flow chart of drug discovery processes



Road towards New Drugs



Imagine that you want to develop a new drug and have it to be approved.

How to plan the strategy and how to conduct the research and put the information/data into a dossier?

To do this, you need specialists in different fields and therefore there are following divisions:

Clinical Research, Pharmacokinetics, Drug delivery, Pharmacoepidemiology and Pharmacoeconomics, Regulatory Science.

How to perform Drug Development?

Data are collected
from many studies, and then one
can apply for clinical trial
permission from
the Investigational New Drug
(IND).

How to perform Drug Development?

It's only after 3 stages of clinical trial, the IND becomes part of the New Drug Application (NDA).

Phase 4 is the stage after the drug is on the market.

In this phase, **pharmacoepidemic methods** are usually used to study and follow up the safety of the new drug during.

Drug Development Steps

1. Preclinical Testing
2. Investigational New Drug Application (IND)
3. Clinical Trials
4. New Drug Application (NDA)
5. Approval

Drug Development - Manufacturing

The drug designated for clinical trials and large-scale
production

has to be manufactured in compliance with

current **Good Manufacturing Practice,**

(cGMP; the word 'current' denotes that regulations
do change from time to time and the current regulations have to be applied),

following authorities requirements,

**EU Directives or International Conference
on Harmonization (ICH) guidelines.**

Regulatory authorities



Drug Development - Manufacturing

Regulatory authorities have the rights
to conduct inspections on pharmaceutical
manufacturing

to ensure they follow cGMP guidelines so that the
drug manufactured is safe and effective.

A **quality system** has to be set up such that the
drug is manufactured in accordance with
approved procedures.

Drug Development - Manufacturing

There must also be traceability of materials as well as appropriate tests being conducted on the raw materials, intermediates and finished products.

The emphasis is that drugs should be safe, pure, effective, and of consistent quality to ensure that they are fit to be used for their intended functions.

Marketing Application

A drug is not permitted for sale until the marketing application for the new drug has been reviewed and approved by regulatory authorities such as the FDA, the EU EMA or Japan's MHLW.

Extensive dossiers are provided to the authorities to demonstrate the safety, potency, efficacy and purity of the drug.

These are provided in the form of laboratory, clinical and manufacturing data, which comply with GLP, GCP and cGMP requirements.

Marketing Application

After the drug has been approved and marketed, there
is

continuous monitoring

(called pharmacovigilance)

of the safety and performance of the drug to ensure
that it is prescribed correctly and adverse events
(side effects) are investigated.

The advertising of drugs is also scrutinised by
regulatory authorities to ensure that there are no
false representations or claims for the drugs.

Pharmacovigilance



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Did You Know?

Total drug development time grew from an average of 8.1 years in the 1960s to 11.6 years in the 1970s, to 14.2 in the 1980s, to 15.3 years for drugs approved from 1990 through 1995.

Pharmaceutical companies and regulatory authorities are working together to reduce this time span.

(The cost of developing a new drug is more than three times the price of a Boeing airplane).

Typically,
tens of thousands of
compounds are screened
and tested, and only a
handful make it into the
market as drug
products.

The statistics are such that,
of 5000 compounds that show
initial promise, five will go
into human clinical trials,
and only one will become an
approved drug.

THE PHARMACEUTICAL INDUSTRY

as we know it today started in the
late 1800s.

It started with the synthetic
versions of natural compounds
in Europe.

THE PHARMACEUTICAL INDUSTRY

A substantial number of the research findings and potential drugs from the start-ups, smaller companies, universities and research organizations are, however, licensed to the multinational pharmaceutical companies for manufacturing, marketing and distribution.

THE PHARMACEUTICAL INDUSTRY

Alternatively, alliances are formed with the multinational pharmaceutical companies to develop or market the drugs, because of the huge cost involved for drug development and commercialisation.

ECONOMICS OF DRUG DISCOVERY AND DEVELOPMENT

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ECONOMICS OF DRUG DISCOVERY AND DEVELOPMENT

The pharmaceutical market is
very competitive.

It is imperative that pharmaceutical
companies, large or small, discover
and develop drugs efficiently and
within the shortest time span to
remain competitive.

TRENDS IN DRUG DISCOVERY AND DEVELOPMENT

The approach to drug discovery and development can generally be classified into the following areas:

1. Irrational Approach
2. Rational Approach
3. Antisense Drugs
4. Biologics
5. Gene Therapy
6. Stem Cell Therapy- both somatic cell and germ cell.

1. Irrational Approach:

This approach is the historical method of
discovering
and developing drugs.

It involves **empirical observations** of the
pharmacological effects from screening of
many chemical compounds,
mainly those from natural products.

1.Irrational Approach means:

The active component that gives rise to the observed effects is isolated.

The chemical formula is determined, and modifications are made to improve its properties.

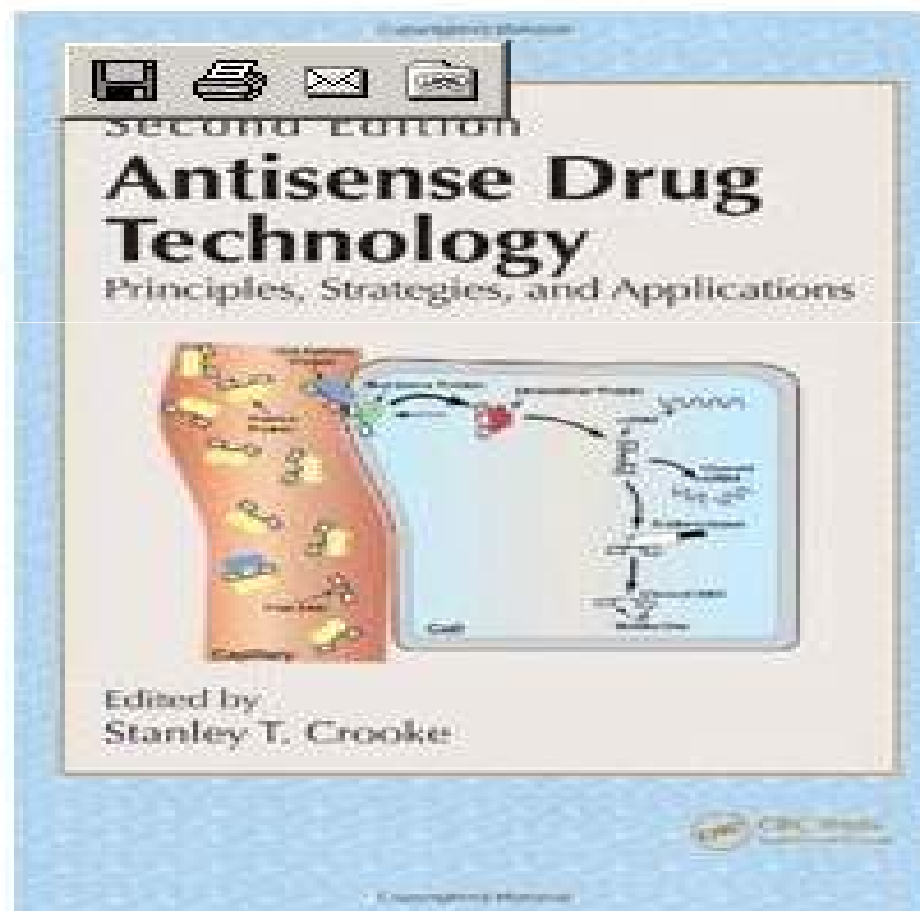
This approach has yielded most drugs available today.

2.Rational Approach:

This approach requires
three-dimensional knowledge
of the target structure involved in the
disease.

Drugs are designed to interact
with this target structure to
create a beneficial response.

**This is an emerging field in drug
discovery.**



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3. Antisense Therapy:

This is a relatively new approach and it requires the modifications to oligonucleotides that can bind to RNA and DNA.

The antisense drugs are used to stop transcriptional (from DNA) or translational (from RNA) pathways from proceeding, and so interfere with the process of disease.

4. Biologics:

These are mainly protein-based drugs in the form of antibodies, vaccines and cytokines. Their discoveries generally start from an understanding of the biological mechanistic pathways that cause specific diseases. Manufacturing of these drugs is based on recombinant DNA technologies using living organisms such as bacteria, yeast and mammalian and insect cells.

Drug research using insects



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Drug research using insects



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5. Gene Therapy:

The basis of this therapy is to remedy a diseased gene or insert a missing gene.

This is a hot new topic that raises many ethical considerations to resolve.

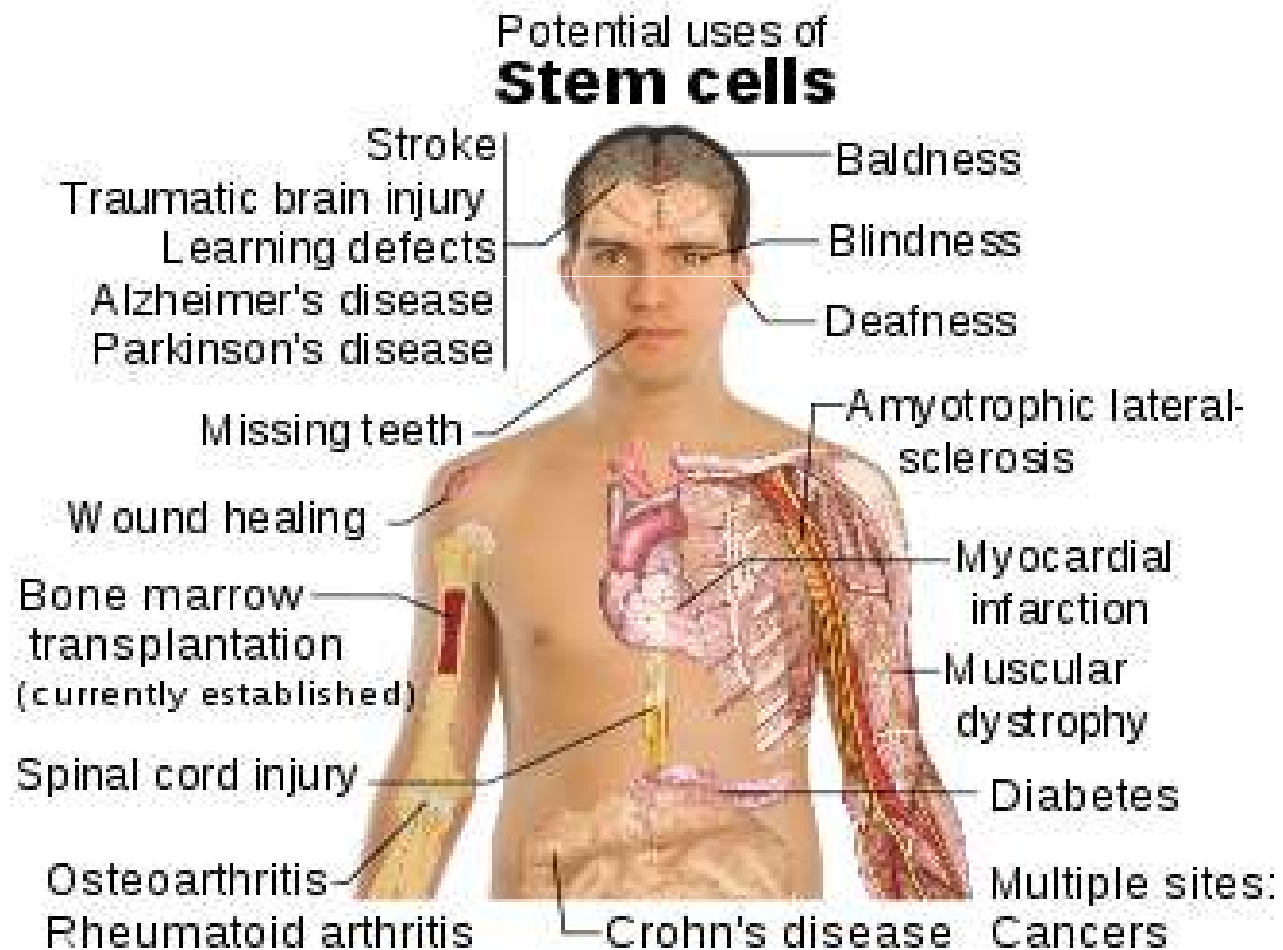
The diseased gene is taken out from a patient, fixed outside the body and then reinserted back into the body.

In the case of missing gene, a copy of the new gene is inserted into the patient. The aim is for the inserted gene to influence the disease pathway or to initiate manufacture of the missing proteins or enzymes.

6. Stem Cell Therapy:

With stem cell therapy, the aim is to grow body parts to replace defective human organs and nerves. The stem cells are harvested from very early embryos or umbilical cord blood. Because of the very young age of these cells, they can be directed to grow into organ tissue to replace diseased tissue.

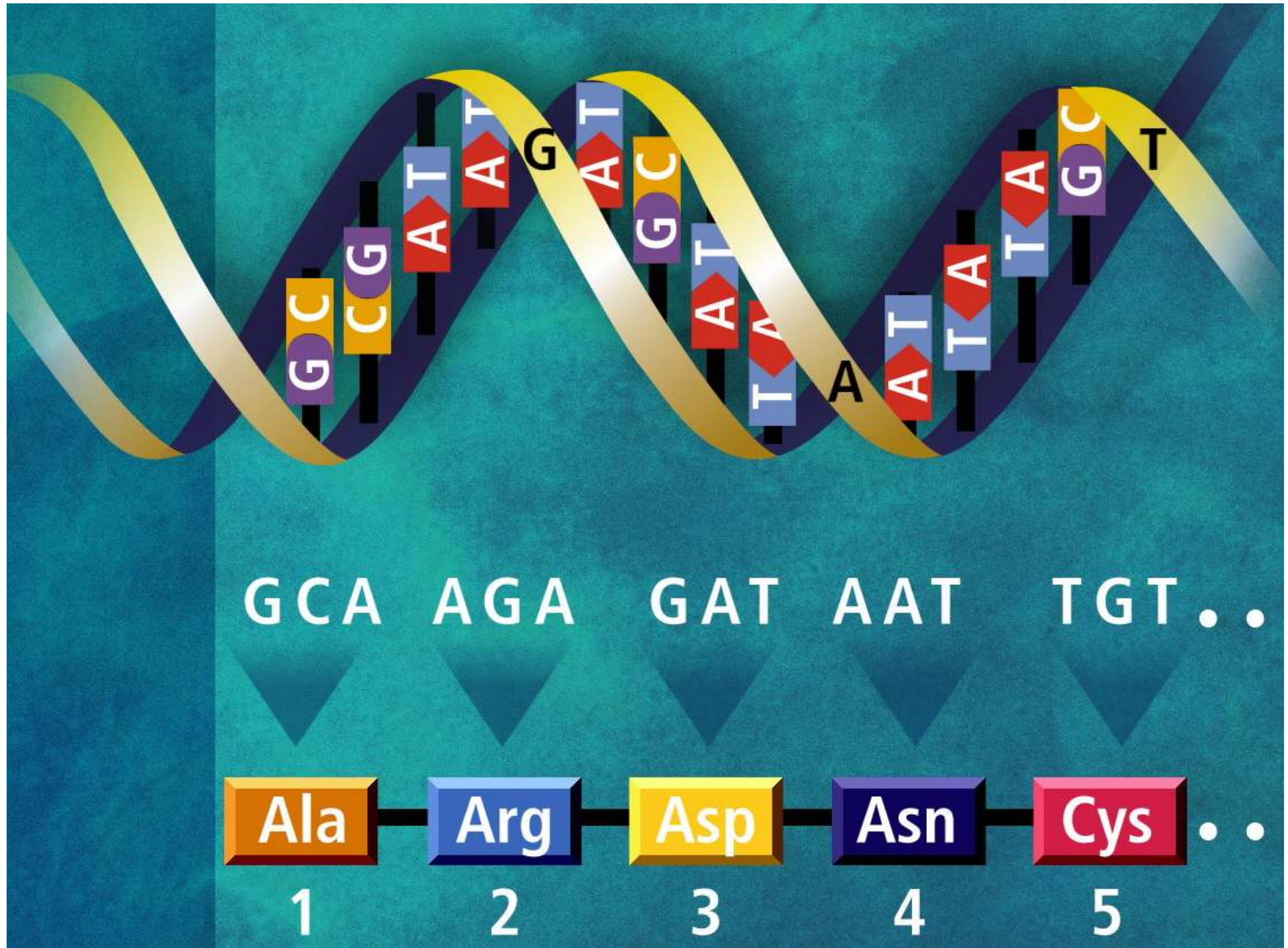
Stem Cell Therapy



The stem cell technology

can provide an alternative to organ transplants with perhaps less rejection problems than the current practice of obtaining parts from another donor person.

Stem cell therapy using germ cells involves cloning, and there are strict **regulatory guidelines** on how research is to be conducted.



Human genomic research

has discovered many novel disease targets,
which can be utilized to develop better and more effective
drugs.

Regardless of the approach used for
discovering new drugs, pharmaceutical
companies are now using a full suite of
technologies to discover and develop new
drugs. These enabling technologies
include:

Information on the human genome

its sequence and what it encodes has been hailed as a potential windfall for drug discovery, promising to virtually eliminate the bottleneck in therapeutic targets that has been one limiting factor on the rate of therapeutic discovery.

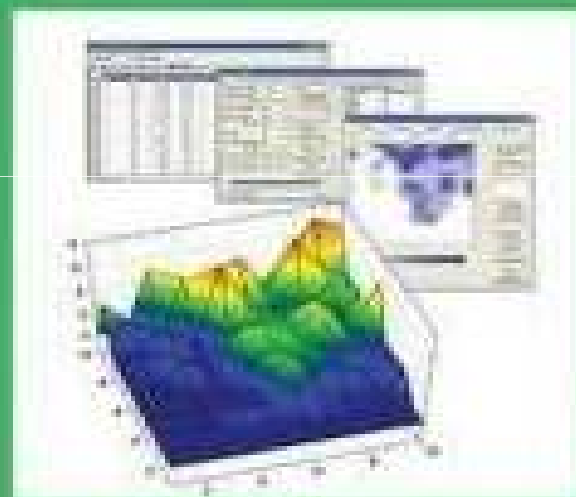
These enabling technologies include:

- Microarray for Disease Target Identification
- High Throughput Screening
- Combinatorial Chemistry
- Structure-Activity Relationships: X-ray Crystallography,
- Nuclear Magnetic Resonance,
- Computational Chemistry
- **Bioinformatics: Data Mining**
- Recombinant DNA Technologies.

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Pharmaceutical Data Mining

APPROACHES AND APPLICATIONS
FOR DRUG DISCOVERY



EDITED BY
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 WILEY

Despite advances in technology and understanding of biological systems

drug discovery is still a
long process with low
rate of new therapeutic
discovery.

The process of finding a new drug

against a chosen target for a particular disease usually involves

High-throughput screening (HTS),
wherein large libraries of chemicals
are tested for their ability to
modify the target.

High throughput screening (or virtual screening)

is a computational technique used in drug discovery research.

It involves the rapid in silico assessment of large libraries of chemical structures in order to identify those structures most likely to bind to a drug target.

High-throughput screening (HTS)

is a method for scientific experimentation
especially used in drug discovery.

HTS allows a researcher to quickly conduct millions of biochemical, genetic or pharmacological tests. Through this process one can rapidly identify active compounds, antibodies or genes which modulate a particular biomolecular pathway.

This data corroborates some thinking underlying a pharmaceutical industry trend beginning at the turn of the twenty-first century and continuing today which finds more risk aversion in target selection among multi-national pharmaceutical companies.

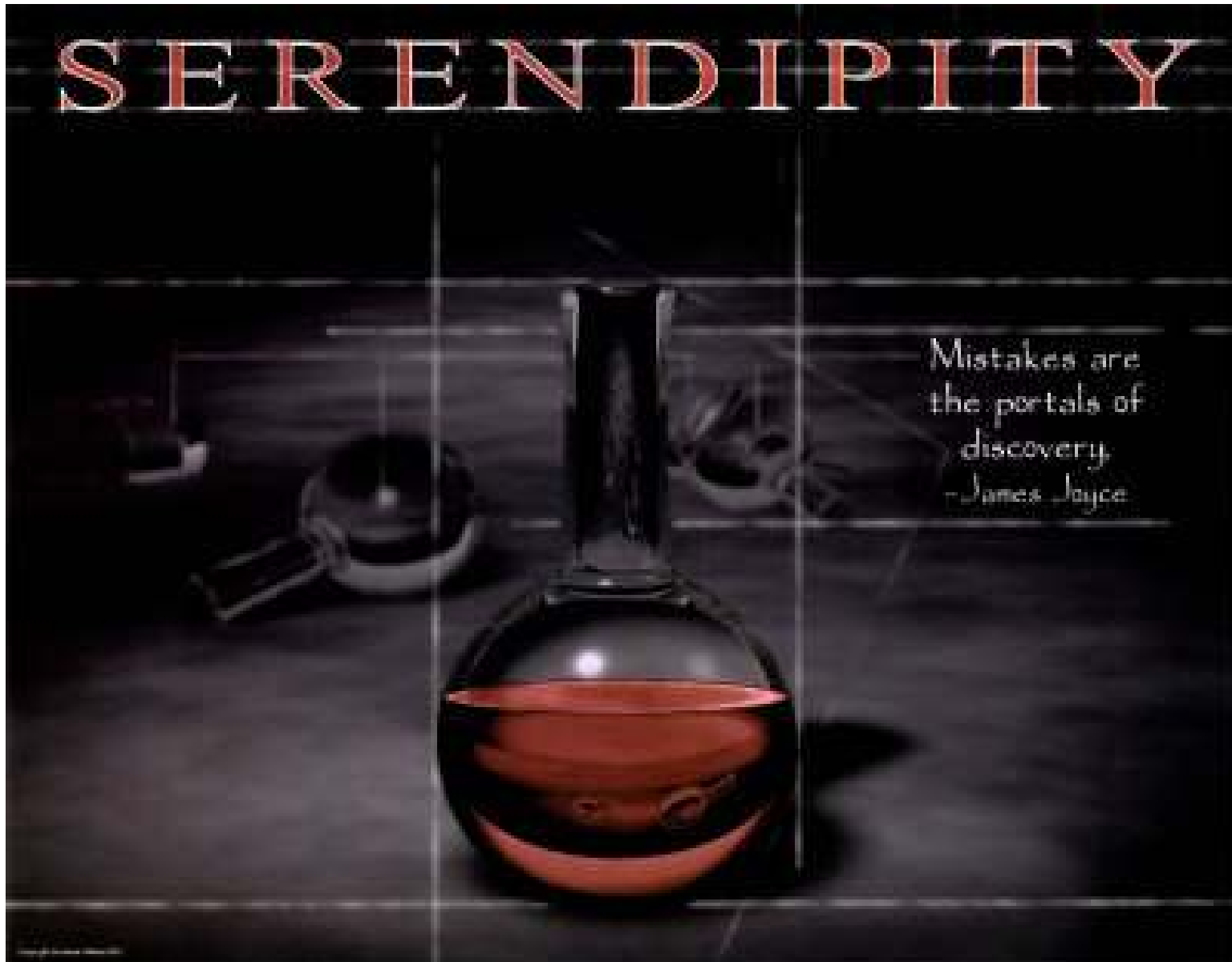
However,

data indicates that "**new targets**" as
opposed to "**established targets**"
are more prone to drug discovery
project failure in general.

In the past
most drugs have been discovered
either by identifying the active
ingredient from traditional
remedies
or by serendipitous discovery

SERENDIPITY

Mistakes are
the portals of
discovery.
- James Joyce



Serendipity is a propensity for making fortunate discoveries, while looking for something unrelated.

The amount of benefit contributed by serendipitous discoveries varies extensively among the several scientific disciplines.

Pharmacy and chemistry are probably the fields where serendipity is more common.

Serendipity

A good luck in making unexpected and fortunate discoveries

Serendipity is the effect by which one accidentally discovers something fortunate, especially while looking for something else entirely.

Controlled accident method.

Some examples:

Viagra (**sildenafil citrate**), an anti-impotence drug. It was initially studied for use in hypertension and angina pectoris. Phase I clinical trials suggested that the drug had little effect on angina, but that it could induce marked penile erections.

Some examples:

The hormone melatonin was discovered in 1917 when it was shown that extract of bovine pineal glands lightened frog skin. In 1958 its chemical structure was defined by Aaron B. Lerner and in the mid-70s it was demonstrated that also in humans the production of melatonin exhibits and influences a circadian rhythm.

Some examples:

The first anti-psychotic drug, chlorpromazine, was discovered by French Henri Laborit.

He wanted to add an anti-histaminic to a combination to prevent surgical shock and noticed that patients treated with it were unusually calm before the operation.

A new approach

has been to understand how disease and infection are controlled at the molecular and physiological level and to target specific entities based on this knowledge.

The process of drug discovery involves

- the identification of candidates,
- synthesis,
- characterization,
- screening,
- and assays for therapeutic efficacy.

Once a compound has shown its value in these tests, it will begin the process of **drug development** prior to clinical trials.

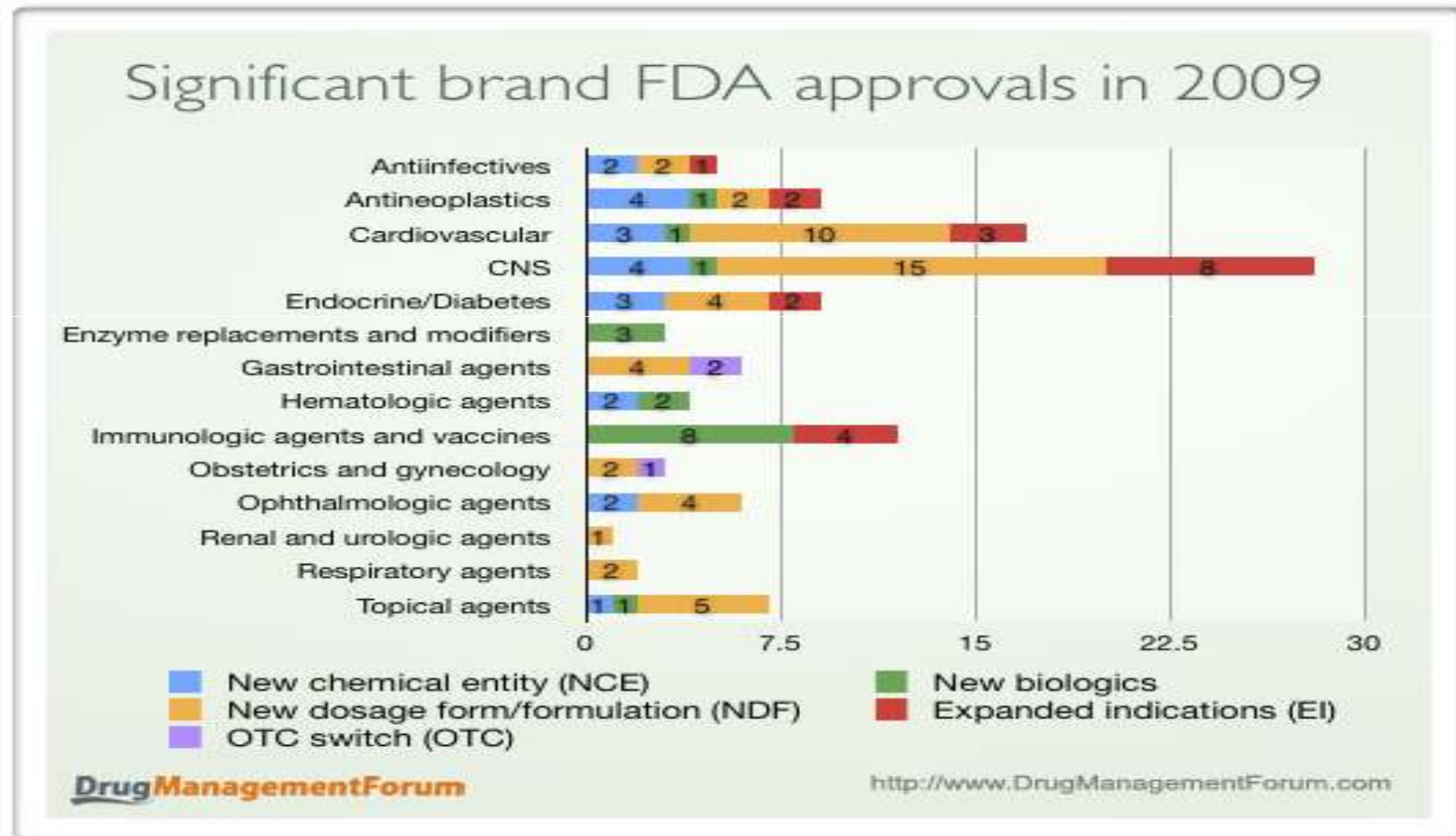
Drug Development or Preclinical Development

is defined in many [pharmaceutical companies](#) as the process of taking a new chemical lead through the stages necessary to allow it to be tested in human clinical trials, although a broader definition would encompass the entire process of drug discovery and clinical testing of novel drug candidates.

New Chemical Entities (NCEs)

are compounds which emerge from the process of drug discovery. These will have promising activity **against a particular biological target** thought to be important in disease, however little will be known about the safety, toxicity, pharmacokinetics and metabolism of this NCE in human.

New Chemical Entities (NCEs)



It is the function of drug development

to assess all of these parameters prior to human clinical trials. A further major objective of drug development is to make a recommendation of the dose and schedule to be used the first time. A NCE is used in a human clinical trial ("First-in-Man", FIM).

In addition

drug development is required to
establish the **physicochemical
properties of the NCE**: its chemical
makeup, stability, solubility.

The process by which the chemical is made

will be optimised so that from being made at
the bench on a milligram scale by a
synthetic chemist, **it can be manufactured**
on the kilogram and then on the ton scale.

It will be further examined
for its suitability to be made into
capsules, tablets or intravenous
formulations.

Together these processes are known in
preclinical development as **CMC**:
Chemistry, Manufacturing and
Control.

Many **aspects** of drug
development
are focused
on satisfying
the regulatory requirements
of drug licensing authorities.

These drug licensing authorities

generally constitute a number of tests designed to determine the major toxicities of a novel compound prior to first use in man.

It is a legal requirement that an assessment of major organ toxicity be performed (effects on the heart and lungs, brain, kidney, liver and digestive system), as well as effects on other parts of the body that might be affected by the drug (e.g. the skin if the new drug is to be delivered through the skin).

While, increasingly, these tests can be made

- using **in vitro methods** (e.g. with isolated cells),
- many tests can only be made by using experimental animals (**in vivo methods**),
- **in silico** assessment of large libraries of chemical structures,

since it is only in an intact organism that the complex interplay of metabolism and drug exposure on toxicity can be examined.

The process of drug development does not stop once a NCE begins human clinical trials.

In addition to the tests required to move a novel drug into the clinic for the first time it is also important to ensure that long-term or **chronic** toxicities are determined, as well as **effects on systems** not previously monitored (**fertility**, **reproduction**, **immune system**, etc). The compound will also be tested for its ability to cause cancer (**carcinogenicity testing**).



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If a compound emerges from
these tests

with an acceptable toxicity and safety profile,
and it can further be demonstrated to have
the desired effect in clinical trials,

then it can be submitted for marketing
approval in the various countries
where it will be sold.

Product approval.

New pharmaceutical products must be
approved by the state authority
as being safe, effective and quality.

The 3 properties:

Safety,

Efficacy,

Quality

The process of product approval

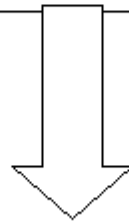
generally involves submission of an Investigational new drug filing with sufficient pre-clinical data to support proceeding with human trials.

Worldwide,
the drug discovery and development are
focused on the same domains like
contemporary nowadays health problems of
civilization, first of all:

- Infections (especially viruses, retroviruses) diseases, (antiinfectives, antivirals),
- Cancer diseases (antineoplastics),
- Cardiovascular diseases (antihypertensives, antihyperlipidemics).

The schematic view on the new drug development

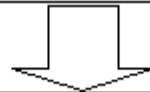
Discovery
Based mostly on systematic research,
including screening of natural
products and/or chemical synthesis.



Physicochemical characterization



Preclinical pharmacological studies



Preclinical toxicological studies



Clinical studies

Phase I: early studies in volunteers

Phase II: early measurements of activity
and dose-finding studies

Phase III: therapeutic trials to establish
efficacy (randomized controlled clinical trials)

The unification of research starting the 20th century:

- in fields such as pharmacy, medicine, chemistry and **increased** the understanding of basic drug-discovery processes.
- **Identifying new drug targets**, attaining regulatory approval from government agencies, and refining techniques in drug discovery and development are among the challenges that face the pharmaceutical industry today.
- **The continual evolution and advancement of the pharmaceutical industry is fundamental in the control and elimination of disease around the world.**

The leaders in terms of pharmaceutical discoveries

Pfizer

GlaxoSmithKline

Novartis

Sanofi-Aventis

AstraZeneca

Hoffmann-La Roche

Johnson & Johnson, ...

Thanks for your
attention