10. What is Science?

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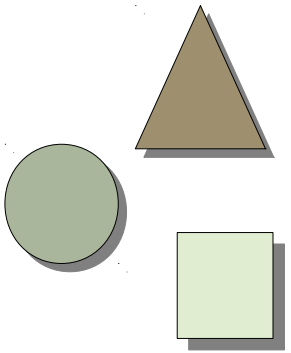
http://st.inf.tu-dresden.de/asics

1) Exact and technical science
2) Data, Information, Knowledge, Wisdom (DIKW)
3) Basic and applied research
4) Computer Science and Software Engineering
5) Dem Schönen Wahren Guten
   - A.1 The Ignorabimus Debate



Obligatory Literature

- Matti Tedre. Know your discipline: Teaching the philosophy of computer science. Journal of Information Technology Education (JITE), 6:105-122, 2007.
- S. T. Redwine, Jr. and W. E. Riddle. Software technology maturation. In 8th International Conference On Software Engineering (ICSE '85), pages 189-200, Washington, D.C., USA, August 1985. IEEE Computer Society Press.

References

- Waldemar Kropp, Alfred Huber. Studienarbeiten interaktiv. Erich-Schmidt-Verlag

Recommended Literature

- [Hey] Jonathan Hey. The Data, Information, Knowledge, Wisdom Chain: The Metaphorical link. Intergovernmental Oceanographic Commission - OceanTeacher: a training system for ocean data and information management.

http://web.archive.org/web/20071202033948/http://ioc.unesco.org/Oceanteacher/OceanTeacher2/02_InfTchSciCmm/DIKWchain.pdf

- Herbert Meschkowski. Was wir wirklich wissen. Die exakten Wissenschaften und ihr Beitrag zur Erkenntnis. Piper Verlag, 1989. ISBN-10: 3492028098. ISBN-13: 978-3492028097. Discusses the limits of exact science, as found out by Gödel, Russel and others.

References

- Herbert Meschkowski. Die Bildung des Menschen durch die exakten Wissenschaften. In: Wissenschaft und Bildung. Vorträge der Berliner Hochschultage, Jan. 1963. Julius Beltz Verlag, Weinheim. Essay about why paradoxies teach thinking and are relevant for Bildung
- C. Zins. Conceptual approaches for defining data, information, and knowledge. Journal of the American Society for Information Science, 2007 - Wiley Online Library, http://www.success.co.il/is/zins_definitions_dik.pdf
- [Hoye] William J. Hoye. Der Grund für die Notwendigkeit des Glaubens nach Thomas von Aquin. Erschienen in: Theologie und Philosophie, 70 (1995), 374–382. http://hoye.de/glauben.pdf
- [Kopetz] Hermann Kopetz. Die Bedeutung von Forschung und Entwicklung für die wirtschaftliche Entwicklung. Slide set on the internet. 2010. Technische Universität Wien
- Wikipedia: Emil_du_Bois-Reymond
- Wikipedia: David_Hilbert

Other Literature

- Prof. Meschkowski has written several interesting history books about science. Fun to read (Bildung!). Get them as used books on Amazon.
- Herbert Meschkowski. Jeder nach seiner Facon. Berliner Geistesleben 1700-1810. Piper-Verlag. Berlin as center of science and rationalism.
- Herbert Meschkowski. Von Humboldt bis Einstein. Berlin als Zentrum der exakten Wissenschaften. Piper-Verlag. On the Nobelprice winners of Berlin and Göttingen around 1850-1930. Why Germany had excellent research back then, before the Jews were expelled by Hitler.
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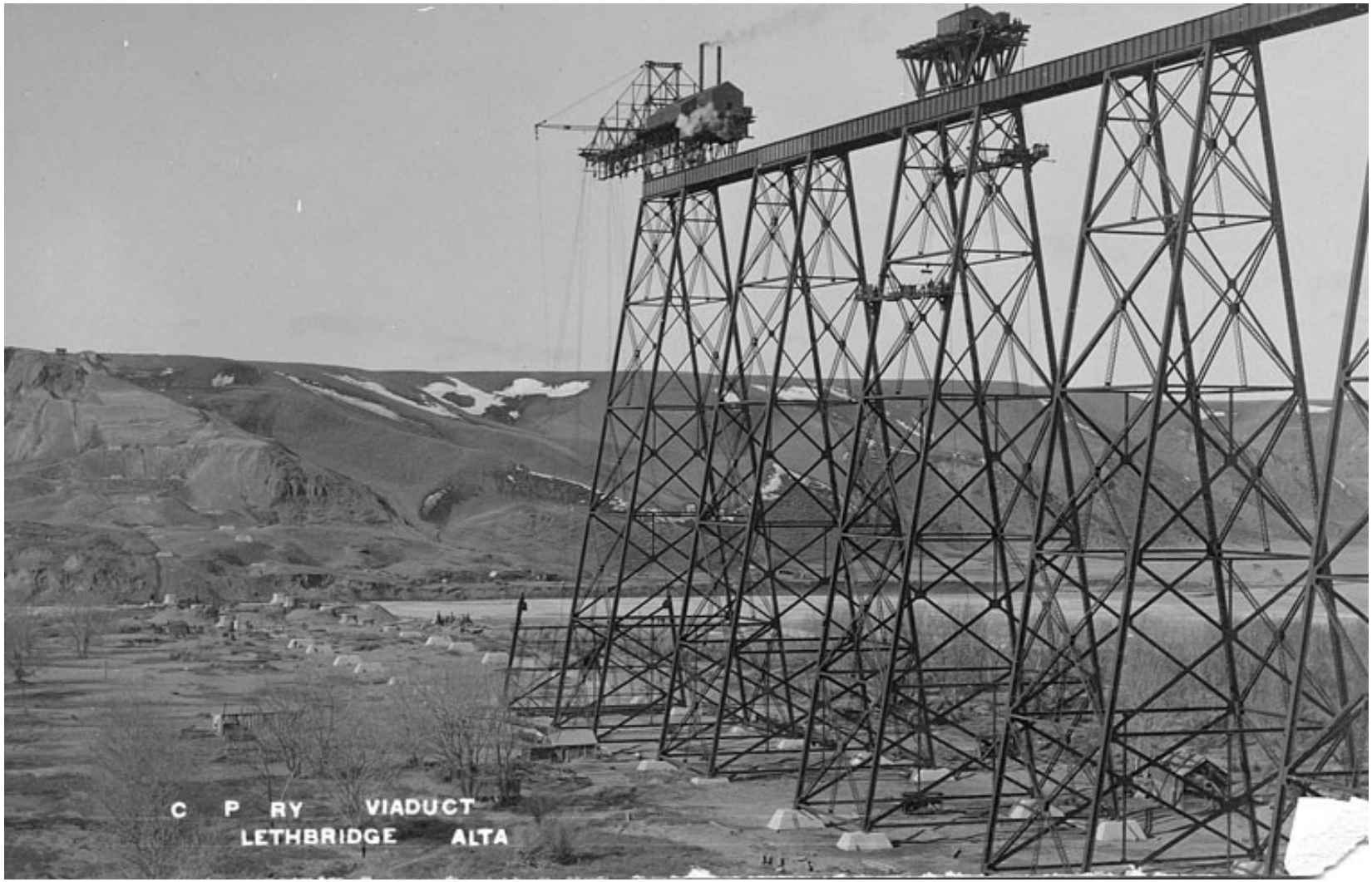
Technical Science Solves Practical Problems



If I have seen further it is by standing on the sholders of Giants.
Isaac Newton

Lethbridge high level bridge. Public domain.
http://www.flickr.com/photos/galt-museum/3380760266/sizes/o/in/photostream/

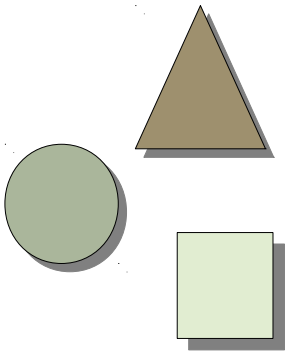
Why Technical Science is Relevant (Homework)

- Read until next week from Helmut Schmidt "Einmischungen", Goldmann, the essay on p. 59
- "Ohne Forschung keine neuen Jobs" (6.12.1996, Die Zeit)
- http://www.zeit.de/1996/50/Forschen_geht_ueber_alles/komplettansicht
- Questions to answer:
  - Which form of science and research does Schmidt have in mind?
  - What is his thesis, his claim?
  - How does he attempt to prove it?
  - Where in the text does he leave his enumeration of arguments?
  - Which paragraphs are the most impressive ones?
  - Why is the last paragraph impressive?

Why are Fachhochschulen (Engineering Schools) Important?

- In Germany, the Bachelor/Master reform has stopped the differenciation of Technical Universities and Fachhochschulen
- Is there a problem?

10.1 Exact Sciences and Technical Science



Exact Science and Formal Science

- An **exact science** is any field of science capable of accurate quantitative expression or precise predictions and rigorous methods of testing hypotheses,

  especially reproducible experiments involving quantifiable predictions and measurements.

- The **formal sciences [structural sciences]** are the branches of knowledge that are concerned with *formal systems*, such as
  - logic, mathematics, theoretical computer science, information theory, game theory, systems theory, decision theory, statistics, and some aspects of linguistics.
- Formal sciences: http://en.wikipedia.org/wiki/Formal_sciences

  Exact science but not formal sciences are the natural sciences.

- Die **exakten Wissenschaften** oder auch **harten Wissenschaften** umfassen diejenigen Wissenschaften, die in der Lage sind, genaue *quantitative* oder *mathematisch* oder *formallogisch präzise* Aussagen zu treffen
und über eigene,
strenge Methoden für die Überprüfung von Hypothesen und vor allem reproduzierbare Versuche mit quantifizierbaren Messungen verfügen.

- **Formalwissenschaften (Strukturwissenschaften)** sind Wissenschaften, die sich der Analyse von Formalen Systemen widmen. Von den Formalwissenschaften werden
  - Logik, Mathematik, allgemeine Linguistik und Theoretische Informatik
- und von den Naturwissenschaften werden
  - Physik, Chemie, sowie Teile der Biologie
- als **exakte Wissenschaften** in diesem Sinne betrachtet.

http://de.wikipedia.org/wiki/Exakte_Wissenschaft

http://de.wikipedia.org/wiki/Formalwissenschaften

The Importance of Basic Research (Vannevar Bush)

[Bush-Endless-Frontier] http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm

Basic research is performed without thought of practical ends. It results in general knowledge and an understanding of nature and its laws. This general knowledge provides the means of answering a large number of important practical problems, though it may not give a complete specific answer to any one of them. The function of applied research is to provide such complete answers. The scientist doing basic research may not be at all interested in the practical applications of his work, yet the further progress of industrial development would eventually stagnate if basic scientific research were long neglected.

One of the peculiarities of basic science is the variety of paths which lead to productive advance. Many of the most important discoveries have come as a result of experiments undertaken with very different purposes in mind. Statistically it is certain that important and highly useful discoveries will result from some fraction of the undertakings in basic science; but the results of any one particular investigation cannot be predicted with accuracy.

Basic research leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science.

Today, it is truer than ever that basic research is the pacemaker of technological progress. In the nineteenth century, Yankee mechanical ingenuity, building largely upon the basic discoveries of European scientists, could greatly advance the technical arts. Now the situation is different.

A nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill.

The Importance of Science for Jobs (Vannevar Bush)

[Bush-Endless-Frontier] http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm

One of our hopes is that after the war there will be full employment, and that the production of goods and services will serve to raise our standard of living. We do not know yet how we shall reach that goal, but it is certain that it can be achieved only by releasing the full creative and productive energies of the American people.

Surely we will not get there by standing still, merely by making the same things we made before and selling them at the same or higher prices. We will not get ahead in international trade unless we offer new and more attractive and cheaper products.

Where will these new products come from? How will we find ways to make better products at lower cost? The answer is clear. There must be a stream of new scientific knowledge to turn the wheels of private and public enterprise. There must be plenty of men and women trained in science and technology for upon them depend both the creation of new knowledge and its **application to practical purposes.**

More and better scientific research is essential to the achievement of our goal of full employment.

The Importance of Industrial Research (Vannevar Bush)

[Bush-Endless-Frontier] http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm

The simplest and most effective way in which the Government can strengthen industrial research is to support basic research and to develop scientific talent.

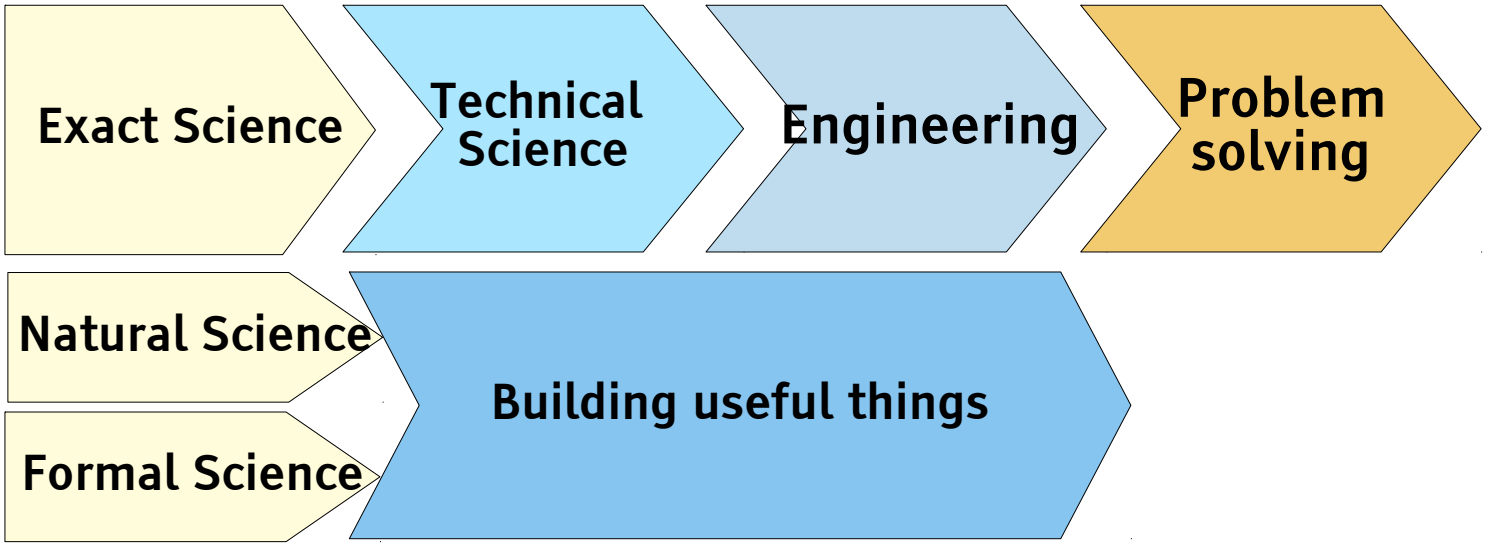
The benefits of basic research do not reach all industries equally or at the same speed. **Some small enterprises never receive any of the benefits**. It has been suggested that the benefits might be better utilized if "research clinics" for such enterprises were to be established. Businessmen would thus be able to make more use of research than they now do. This proposal is certainly worthy of further study.

One of the most important factors affecting the amount of industrial research is the income-tax law. Government action in respect to this subject will affect the rate of technical progress in industry. Uncertainties as to the attitude of the Bureau of Internal Revenue regarding the deduction of research and development expenses are a deterrent to research expenditure. These uncertainties arise from lack of clarity of the tax law as to the proper treatment of such costs.

The Internal Revenue Code should be amended to remove present uncertainties in regard to the deductibility of research and development expenditures as current charges against net income.

Technical Science (Technikwissenschaft)

- **Applied science (Technical science)** uses human knowledge to develop methods and techniques to build or design useful things.
  - Eine **Technikwissenschaft** nutzt die Ergebnisse der exakten Wissenschaften, um Verfahren herauszufinden, nützliche Dinge zu bauen und für den Menschen praktische Probleme zu lösen.
- **Engineering (Ingenieurswesen)** uses the results of technical science to build useful things.
- Technical science must be exact to solve problems!



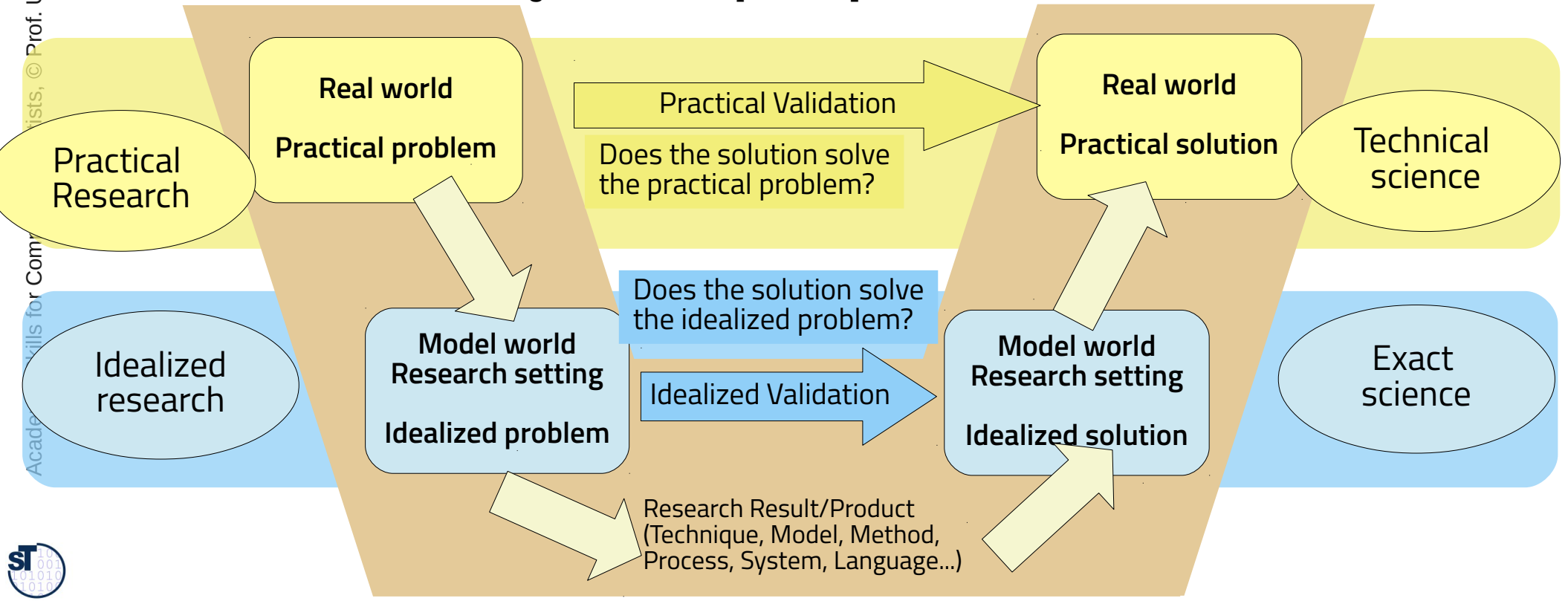
http://en.wikipedia.org/wiki/Applied_science

Technical Science Solves Practical Problems

http://www.flickr.com/photos/galt-museum/3379939843/sizes/o/in/photostream/

Practical Research vs. Idealized Research

- [Shaw-ETAPS02] Many research papers and solutions require a *model of reality* in which their result is valid. A **model of reality** is an idealized abstraction of reality
- An **idealized research problem** is a research problem in a model of reality, a **complete (practical) research** result solves a practical research problem
- **Structural science** (mathematics, theoretical computer science, computer science) works in idealized model worlds
- Technical science (engineering science), also Software Engineering, works for **practical problems** and must research **practical solutions**
- **Technical scientists and Engineers** have to produce **practical solutions**



The Beauty of Exact Science

One reason why mathematics enjoys special esteem, above all other sciences, is that its laws are absolutely certain and indisputable, while those of other sciences are to some extent debatable and in constant danger of being overthrown by newly discovered facts."

Albert Einstein

http://en.wikipedia.org/wiki/Formal_sciences

The Beauty of Technical Science

"Es gibt nichts Praktischeres als eine gute Theorie." - Kurt Lewin, auch David Hilbert und Immanuel Kant

"Nichts ist praktischer, als eine gute Theorie." - Todor Karman

Eine gute Theorie ist das Praktischste, was es gibt." - Gustav Robert Kirchhoff

http://www.humboldt.hu/HN20/werk.htm

http://de.wikiquote.org/wiki/Diskussion:Theorie

10.2 Data, Information, Knowledge, and Wisdom

- Science should produce knowledge, and technical science should solve problems

Where is the Life we have lost in living?

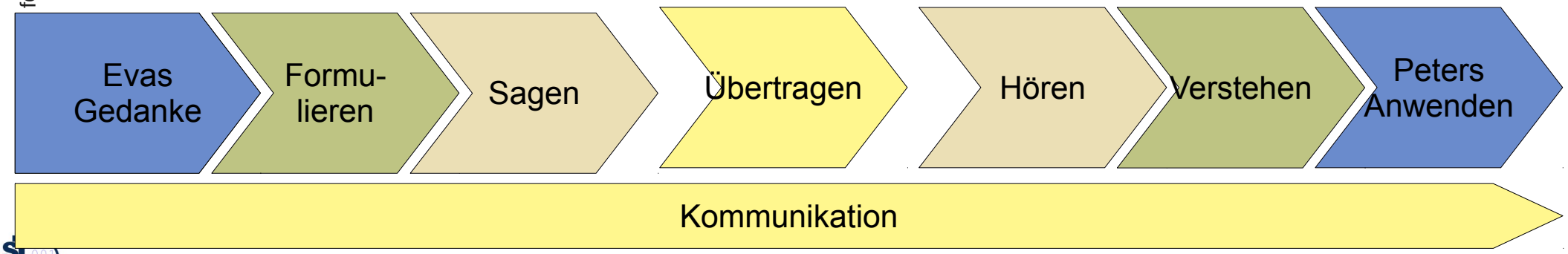
Where is the wisdom we have lost in knowledge?

Where is the knowledge we have lost in information?

T.S. Eliot, "The Rock", Faber & Faber 1934. [Hey]

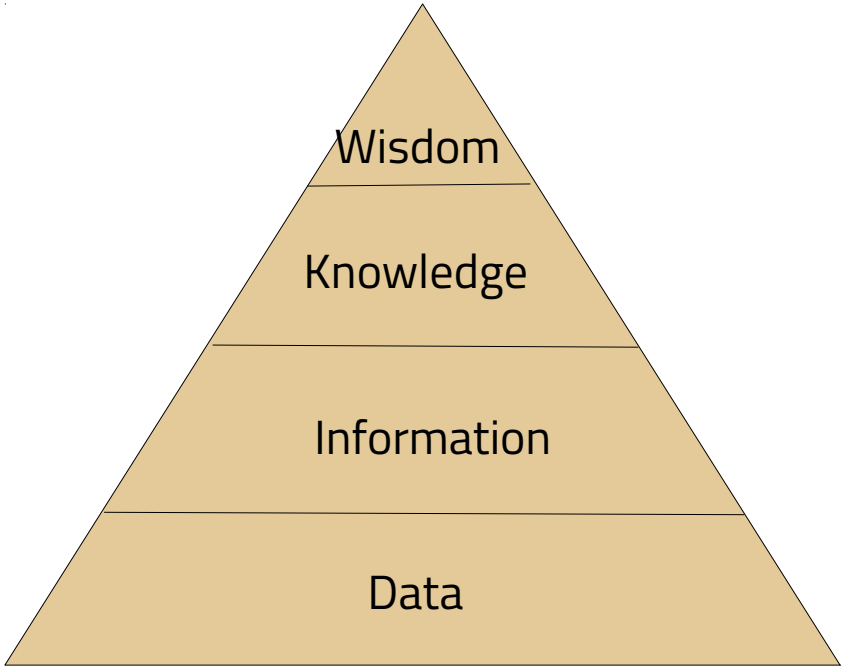
Communication as a Channel Model

Gedacht heißt nicht immer gesagt,
gesagt heißt nicht immer richtig gehört,
gehört heißt nicht immer richtig verstanden,
verstanden heißt nicht immer einverstanden,
einverstanden heißt nicht immer angewendet,
angewendet heißt noch lange nicht beibehalten.
Konrad Lorenz



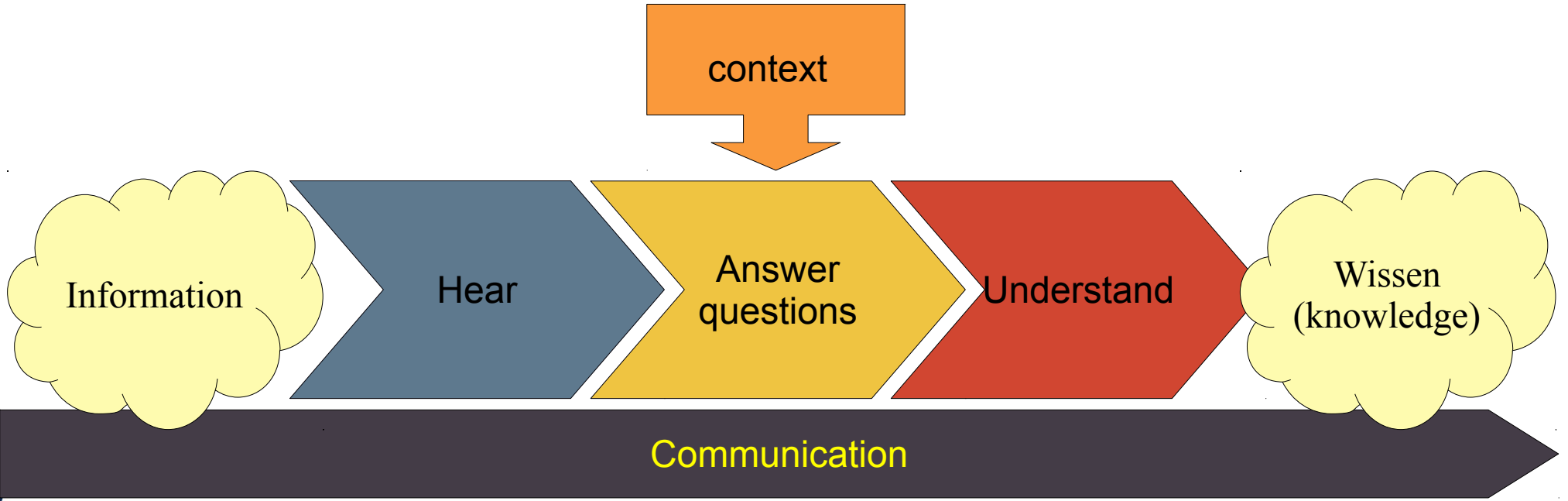
Science is about DIKW (Data, Information, Knowledge, Wisdom)

- Philosophy of Science (Wissenschaftstheorie) discusses the right model for DIKW.
- The relationship of DIK and W is important for science, because
  - Natural science finds data in the world and has to interpret them to knowledge
  - Technical science should use knowledge to solve problems, but needs to be wise, because technology can be dangerous (e.g., see the use of nuclear energy)
- One DIKW model is the DIKW pyramid:



The DIK Model from Spinner

- Knowledge is context-dependent and gained from information by interpretation
  [Prof. Helmut Spinner, Karlsruhe, Keynote at Fakultät Informatik, 1997]
- Every human being judges on a message immediately, answering 10-15 questions immediately
- Answering the questions creates knowledge
- What do I think about information such as:
  - "Das schmeckt gut."
  - "Das ist aber interessant"
  - "Du Idiot"
  - "Du bist ein Schlingel"
  - "Du bist aber schlau"



Typical Questions for Interpretation

About the sender:

- In which emotional state is the sender? (angry, sad, happy, joking, serious)
- Is the sender trustworthy? (unknown, friend, competitor, enemy, have I been disappointed by him already?)
- Which personality has the sender? (serious human being, funny, thinker, surperfical type, depressive,...)
- which channel has the sender used previously (facts, emotions, relations, etc.)?

About the receiver:

- Which are my current expectations? Which channel do I expect?
- My emotional state

About the context:

- In which state is the relationship (peace, quarrel, ..)
- the communikation? (stress, hurry, joking, ..)

How Information Becomes Knowledge

- How do you interpret the remarks
  - “Das schmeckt gut.”
  - “Das ist aber interessant”
  - “Du Idiot”
  - “Du bist ein Schlingel”
  - “Du bist aber schlau”
- from your partner?
- from your friend?
- from your mother?
- from your competitor?
- from your boss?

Knowledge is what remains after answering questions.

Knowledge is what remains in the scientist after answering questions of his value system.

Exc.: What is "Chicken Soup for the Soul"?

- What is Chicken Soup?
- Why is it good?
- Why is it good for the soul?
- What does it really mean?
- Why is here data and information completely based on association?

10.2.2 Different Forms of "Know"

- Give for all terms an example sentence
- Knowledge (Wissen)
- Faith (Glaube)
- Certitude (Gewissheit)
- Assumption (Annahme)

Different Forms of "Know"

Objective

Subjective

everybody can prove this himself by experiment or proof

historically well established sources or eye-whitnesses

Experience by subjective experiments

Only seen or experienced by me Memory Revelation

Knowledge

Well-founded assumptions

Certitude

Faith

Exact Sciences
John is my father by DNA test

Historical sciences
John is my father

I will make it

Plays a role in court
Judy loves me

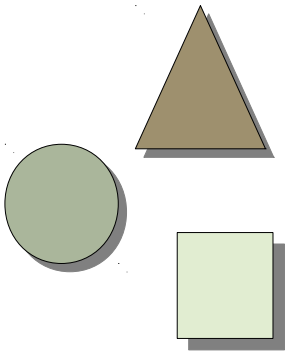
Bertrand Russel on "Know"

[Russel-Problems]

In daily life, we assume as certain many things which, on a closer scrutiny, are found to be so full of apparent contradictions that only a great amount of thought enables us to know what it is that we really may believe. In the search for certainty, it is natural to begin with our present experiences, and in some sense, no doubt, knowledge is to be derived from them. But any statement as to what it is that our immediate experiences make us know is very likely to be wrong. It seems to me that I am now sitting in a chair, at a table of a certain shape, on which I see sheets of paper with writing or print. By turning my head I see out of the window buildings and clouds and the sun. I believe that the sun is about ninety-three million miles from the earth; that it is a hot globe many times bigger than the earth; that, owing to the earth's rotation, it rises every morning, and will continue to do so for an indefinite time in the future. I believe that, if any other normal person comes into my room, he will see the same chairs and tables and books and papers as I see, and that the table which I see is the same as the table which I feel pressing against my arm. All this seems to be so evident as to be hardly worth stating, except in answer to a man who doubts whether I know anything. Yet all this may be reasonably doubted, and all of it requires much careful discussion before we can be sure that we have stated it in a form that is wholly true.

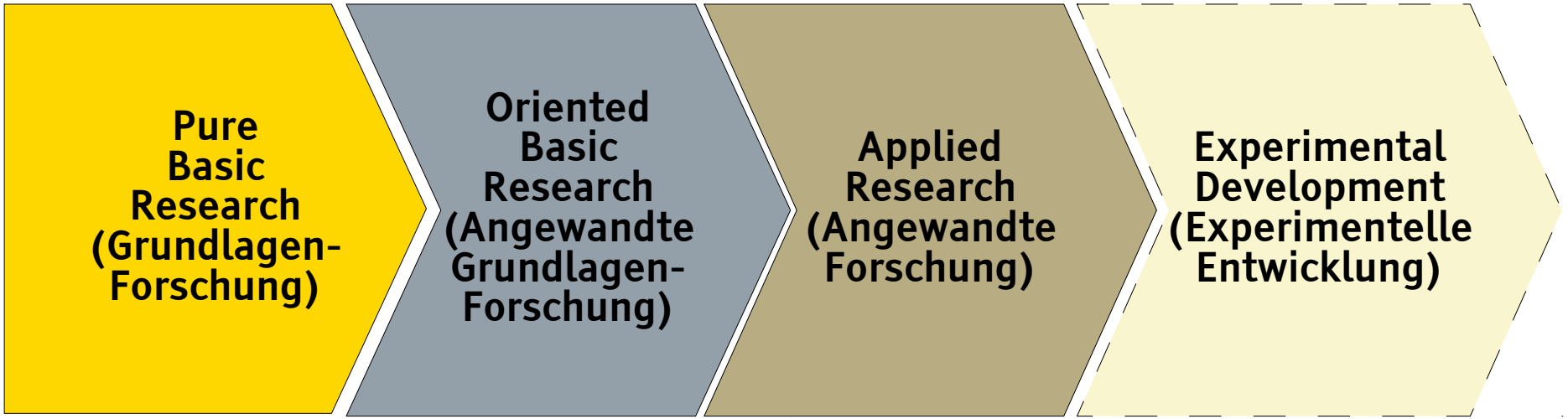
Do you want to know why this text reads well? Then, visit the course.

10.3 Different Forms of Research: Basic and Technology Research



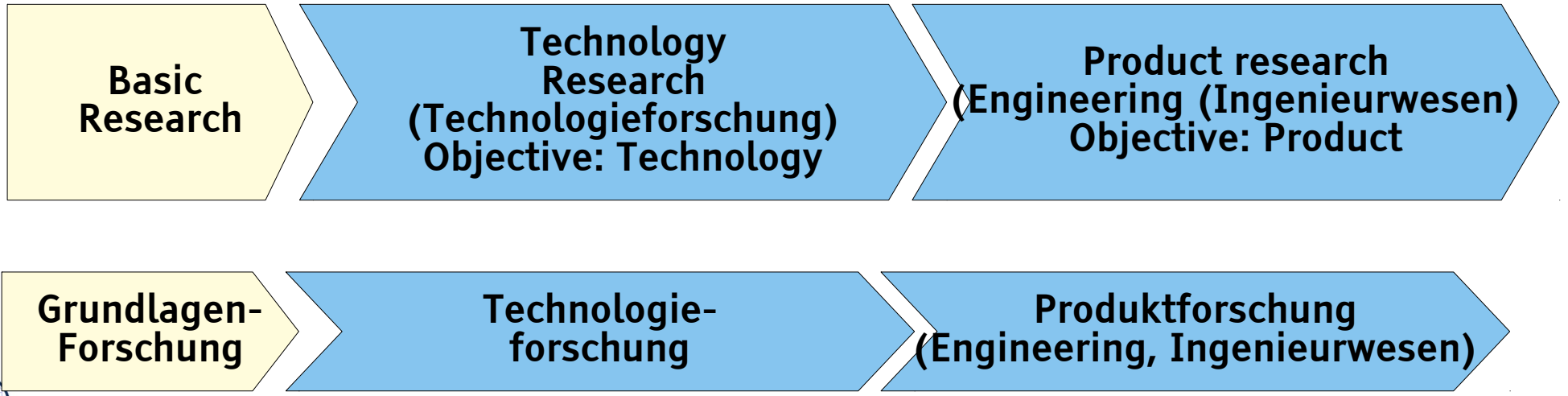
Definition of the OECD 1970

- The research model of the Frascati-Manual [Töpfer]



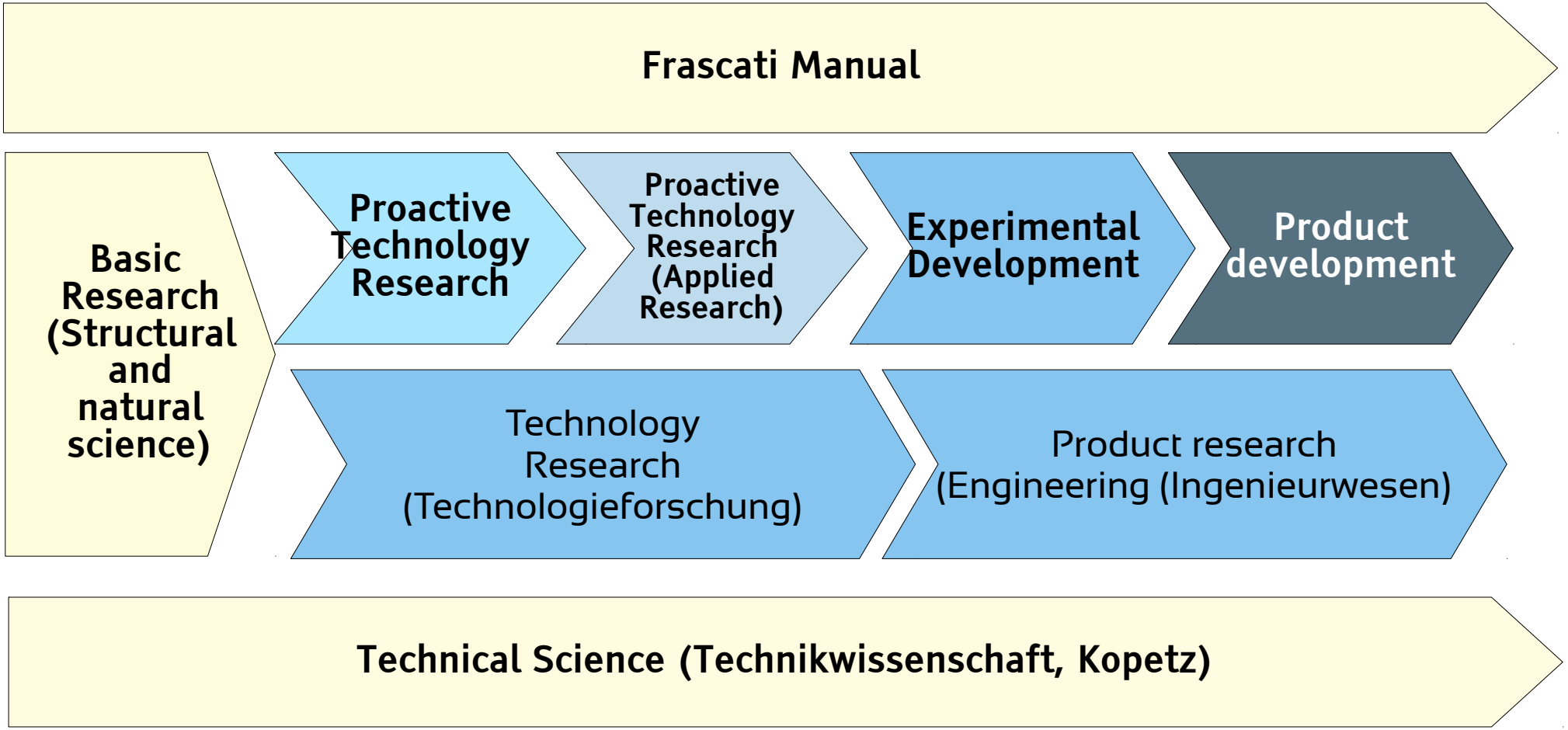
Basic Research and Technology Science (Technologiewissenschaft): The ResearchModel from [Kopetz]

- Basic research is different from research of technologies.
- Hermann Kopetz, TU Vienna: In technical sciences, there is basic research, technology resarch, and engineering:
  - **Basic research** is most often structural science (mathematics, theoretical computer science, theoretical physics)
  - **Technology science (Technologiewissenschaft)** takes these results and develops methods and techniques for engineering.
  - **Engineering (Experimental development, Produktforschung):** Engineers use technologies and results of applied research to experimentally develop prototypes, later products



Technology Research (Technologieforschung)

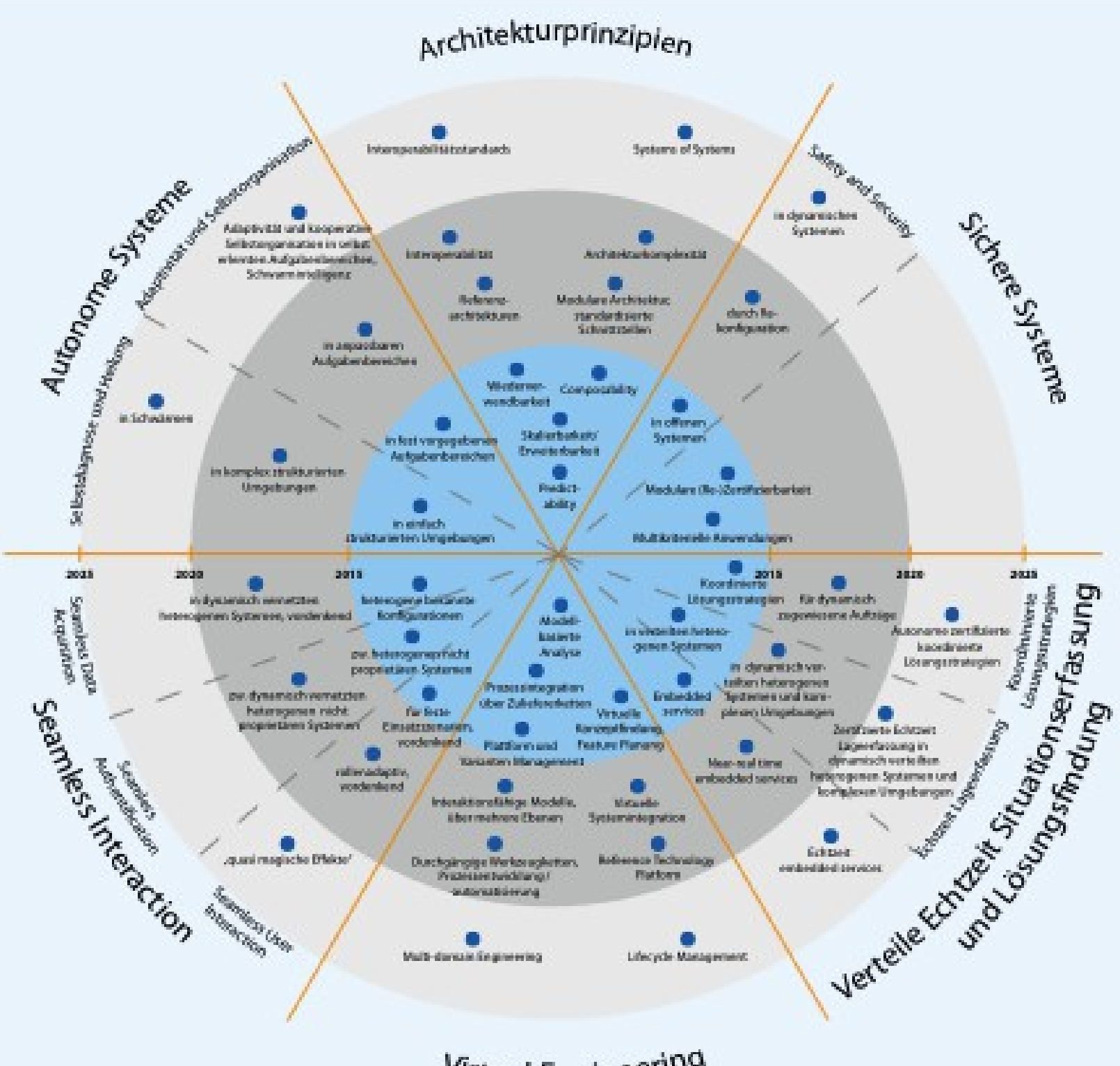
- According to Frascati Manual and Kopetz
- Technology research can be *proactive* or *reactive*



Both Models (OECD, Kopetz) Unified

Exc. Research about Future Embedded Systems

- Dec 2009, the ZVEI and BITKOM published a "National Roadmap Embedded Systems"
- Study the roadmap. Look at Figure 1 on page 51 and classify:
  - Research problems 5 years in advance
  - 10 years in advance
  - 15 years in advance
- What are
  - Basic research problems
  - Technical science problems
  - Applied research problems



Exc. Research about Cyber-Physical Systems

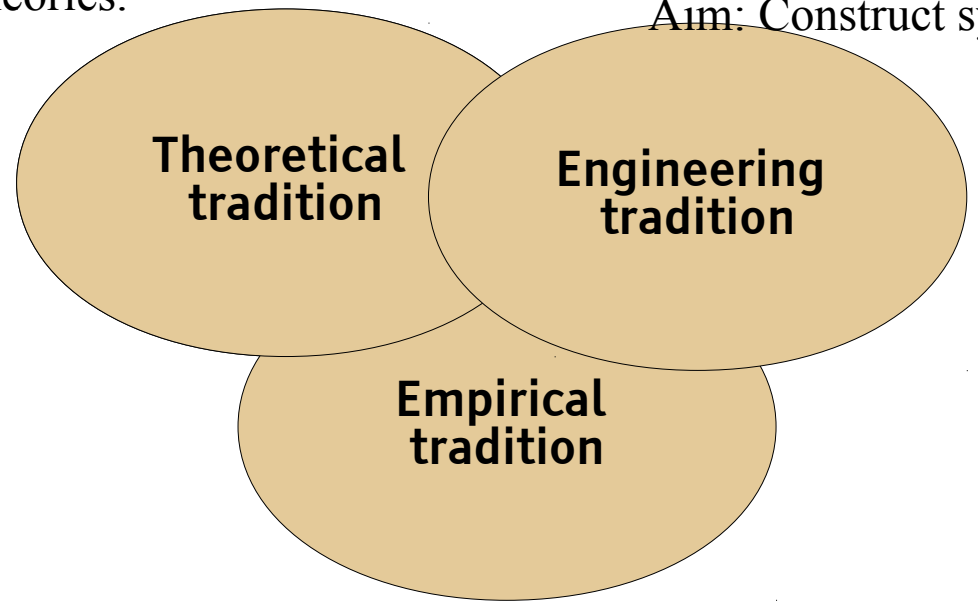
- Since 2007, there is a new German National Academy for Technical Sciences (Technikwissenschaften), Acatech www.acatech.de
- 500 professors are called to serve for public consultancy
- Study the "agendaCPS" report and classify:
  - Basic research problems
  - Technical science problems
  - Applied research problems
- http://www.acatech.de/de/publikationen/empfehlungen/acatech/detail/artikel/acatech-studie-agendacps-integrierte-forschungsagenda-cyber-physical-systems.html

What is "Informatik"/"Computer Science"?

- Matti Tedre. Know Your Discipline: Teaching the Philosophy of Computer Science

Creating hypotheses/theorems
Proving them
Aim: coherent theories.

Stating requirements and specifications
designing, implementing, testing
Aim: Construct systems, solve problems



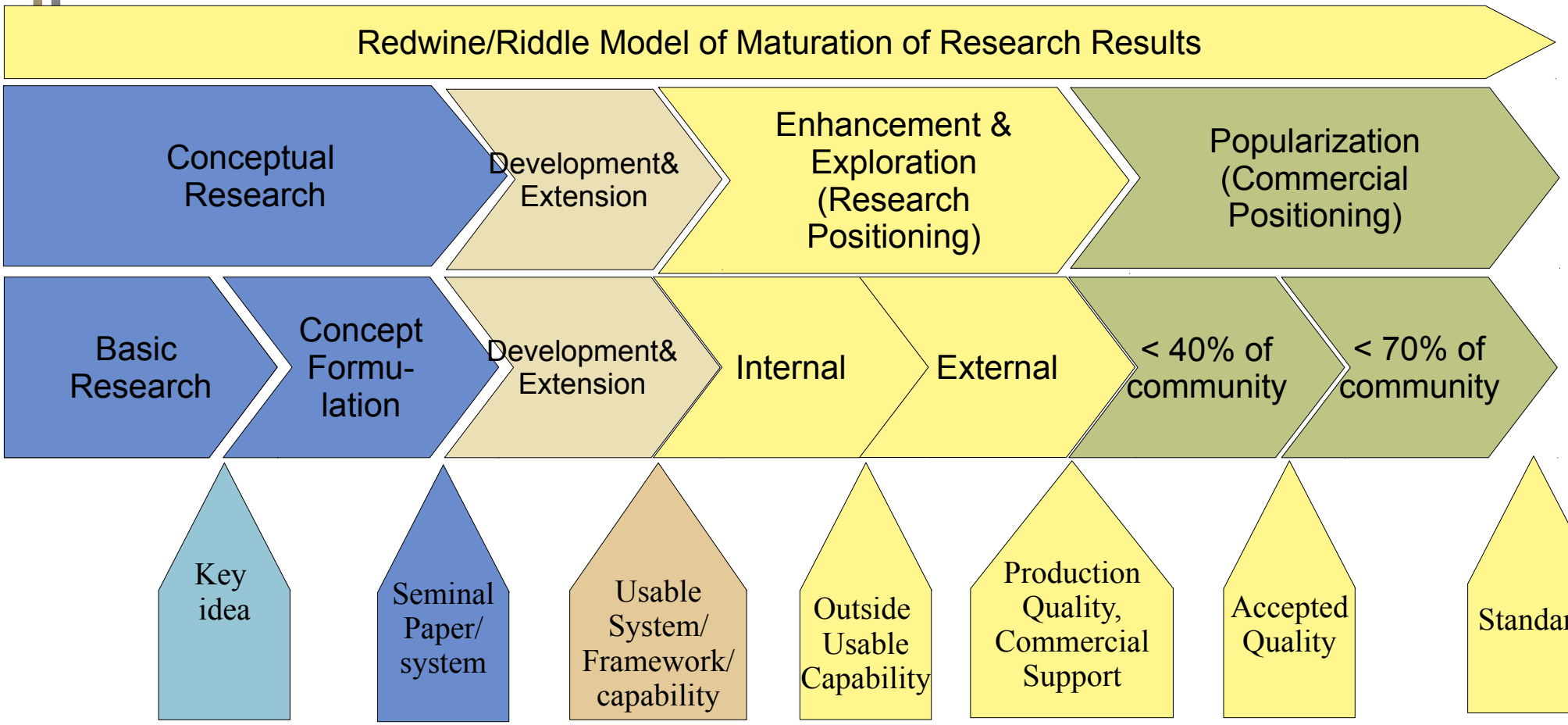
Creating hypotheses, models, predications
Experimenting and collecting data; analyzsing results
Aim: investigate and explain phenomena

In this sense, computer scientists are expected to be *bricoleurs*, sort of academic jacks-of-all-trades.

Meta-Analysis of Research

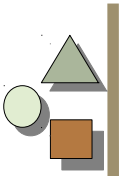
- von Kropp/Huber, Studienarbeiten interaktiv.
- Grundlagenaspekte
  - Definition, Wesensmerkmale erkennen, Aufzählen, Arten/Formen (Klassifikation), Zwecke, Ziele Aufgaben
- Analytische Aspekte
  - Vergleichen, Strukturieren, Meinungen gegenüberstellen, Voraussetzungen klären, Konsequenzen aufschlüsseln
- Syntese und Bewertung
  - Stellung nehmen, kritisieren, Schlussfolgern, Begründen, Bewerten, Beziehungen herstellen Zusammenfassen
- Praxis/Empireaspekte
  - Beispiele, Entscheidungsfälle, Problemfälle, Experimente, Empirische Befunde

Redwine-Riddle Model of Technology and Research Maturization



10.4 Computer Science and Software Engineering

- Definitions of ACM:
- ACM Computing Curricula 2005. The Overview Report covering undergraduate degree programs in Computer Engineering, Computer Science, Information Systems, Information Technology, Software Engineering. The Joint Task Force for Computing Curricula 2005.
  - A cooperative project of The Association for Computing Machinery (ACM), The Association for Information Systems (AIS), The Computer Society (IEEE-CS), 30 September 2005
- http://www.acm.org/education/education/curric_vols/CC2005-March06Final.pdf



Computer Science

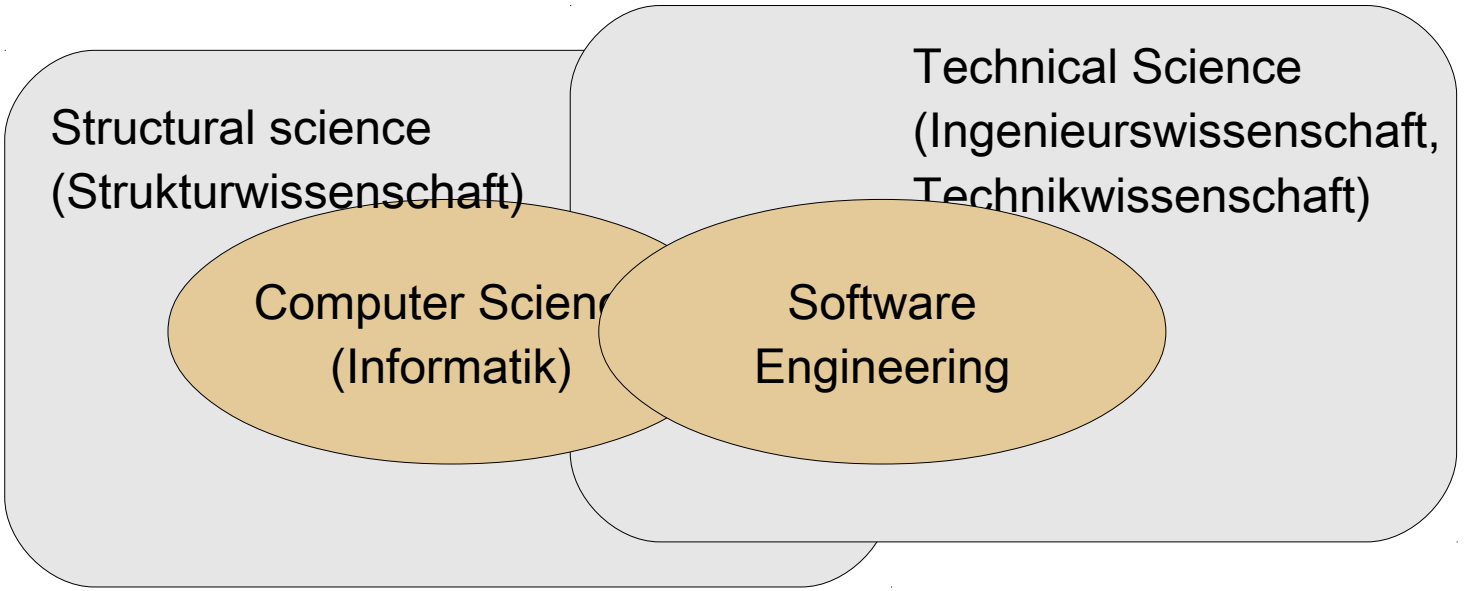
- Computer science spans a **wide range**, from its **theoretical** and **algorithmic foundations** to **cutting-edge developments** in robotics, computer vision, intelligent systems, bioinformatics, and other exciting areas.
- 3 categories of computer scientists:
  - They design and implement software.
  - They devise new ways to use computers.
  - They develop effective ways to solve computing problems.

Software Engineering

- Software engineering is the discipline of **developing and maintaining** software systems that behave **reliably and efficiently**, are affordable to develop and maintain, and satisfy all the **requirements** that customers have defined for them.
- .. it has evolved in response to factors such as the growing impact of **large and expensive** software systems .. in **safety-critical** applications.
- It seeks to integrate the principles of mathematics and computer science with the **engineering practices** developed for tangible, physical artifacts.
- Degree programs in computer science and in software engineering have many courses **in common**.
  - Software engineering students learn more about software **reliability and maintenance** and **focus** more on techniques for **developing and maintaining** software that is **correct** from its inception.
  - While CS students are likely to have heard of the importance of such techniques, the **engineering** knowledge and experience provided in SE programs go beyond what CS programs can provide.
- The importance of this fact is so great that one of the recommendations of the SE report is that, during their program of study, students of SE should participate in the development of software to be used in earnest by others.

Informatik and Software Engineering

- Structural Science
  - Analytics
  - Descriptive
- Technical Science
  - Construction
  - Models with predictable features
  - Application of analytical and descriptive models



Specifics of Software Engineering

- Management of the architecture of large systems
  - Programming-in-the-large vs programming-in-the-small
- Project management
- Economic knowhow
  - Costs, Return-on-Investement

Software Engineering can be oriented Towards Design or Empirics - Masters Programs

- **Software architecture**
  - Vienna: SE und Internet Computing
  - Lugano: Software Design
- **Empirical SE, Processes:**
  - European Masters on Software Engineering
    - IESE Kaiserslautern
    - Blekinge, Bolzano, Madrid

Software Engineering and Internet Computing der TU Wien	**EMSE**
Sprache deutsch	Sprache Englisch; Erasmus Mundus basierter Austausch und Doppeldiplome
Module	**Module**
Allgemeine Basislehrveranstaltungen	Requirements Engineering
Software-Entwicklung	Software Project Management
Theoretische Informatik	Verification and Validation
Wirtschaft und Management	Advanced Project Management
Verteilte Systeme und Internet Computing	Advanced Modules
Wahllehrveranstaltungen (Vertiefungsfach)	*Empirical Software Engineering*
Freie Wahlfächer und Soft Skills	*Software Quality*

Why are Fachhochschulen (Engineering Schools) Different?

- In Germany, the Bachelor/Master reform has stopped the differenciation of Technical Universities and Fachhochschulen
- What is the problem?

Old:

Fachhochschule

focus on practice of engineering:
2 semester internships in companies

Technische Universität

scientific education in a technical science: focus is on method development

---

New:

Fachhochschule Bachelor

FH Master

focus on ??
2 semester internships in companies lost
1 year master doesnt deserve the title

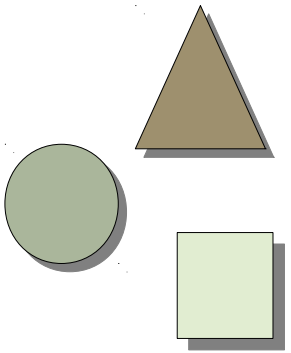
Technische Universität

TU Master

Vordiplom (school) is now 3 years
Interchangeabilty is not really guaranteed
engineering and technical science are no longer distinguished!

One problem is that the difference of engineering and technical science (Ingenieurswissenschaft) has been forgotten

10.6 Das Schöne, Wahre, Gute in der Wissenschaft

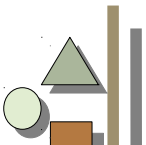


What is Science?

http://www.flickr.com/photos/57198511@N00/3739119954/sizes/m/in/photostream/

The Reason for Science: The Beauty

- In his essay “The weight of Glory” (“Das Gewicht der Herrlichkeit”), the philosopher C.S. Lewis claims that all we long is glory (das Schöne Wahre Gute).
- Science helps to finds it out
- He also claims that it has to do with the Godly, with the desire to be known by God.
- Science is about knowing. Knowing is something Godly.



E - Exercises

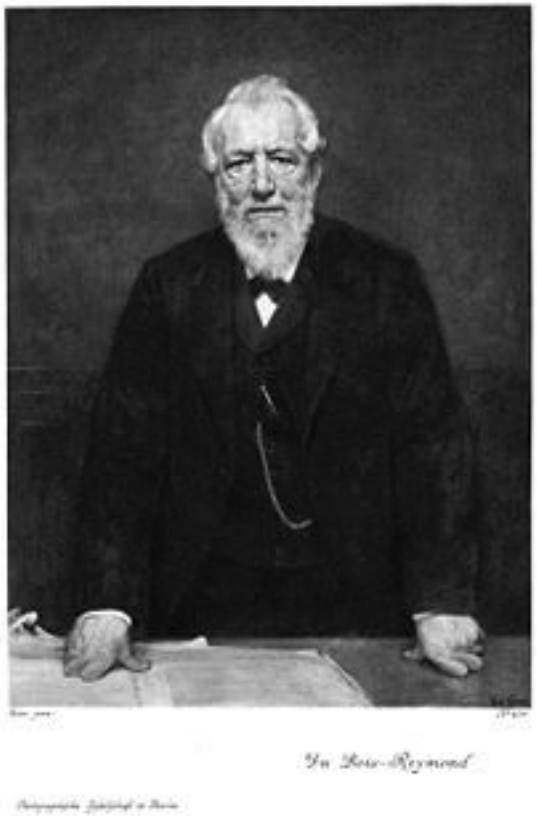
Why Technical Science is Relevant (Answer to Last Homework)

- Helmut Schmidt "Einmischungen", Goldmann, the essay on p. 59
- "Ohne Forschung keine neuen Jobs" (6.12.1996, Die Zeit)
- Questions to answer:
  - Which form of science and research does Schmidt have in mind?
    - Applied research, Technologieforschung, aber auch Grundlagenforschung
    - Er weiß nicht, wie man Push-Technologietransfer macht
  - What is his thesis, his claim? "The sting is in the tail"
    - Deutschland muss innovativer werden, um den Lebensstandard zu halten
  - How does he attempt to prove it?
    - Enumeration of 7 Arguments (7-step, 7-rhombus)
  - Where in the text does he leave his enumeration of arguments?
    - He puts much effort into the last "The sting is in the tail"
  - Which paragraphs are the most impressive ones?
    - The last one, because it is emotional and pathetic
  - Why is the last paragraph impressive?
    - Because it has a strong appeal

A.1 The Ignorabimus Debate – The Limits of the Exact Sciences, Exact Knowledge, and Different Forms of Rationalising

Has exact science limits?
How do we gain hard, exact, objective knowledge?

“Wir werden es nicht wissen” (“Ignorabimus”)



„Gegenüber den Rätseln der Körperwelt ist der Naturforscher längst gewöhnt, mit männlicher Entsagung sein „Ignoramus“ auszusprechen.

Im Rückblick auf die durchlaufene siegreiche Bahn trägt ihn dabei das stille Bewußtsein, daß, wo er jetzt nicht weiß, er wenigstens unter Umständen wissen könnte, und dereinst vielleicht wissen wird.

Gegenüber dem Rätsel aber, was Materie und Kraft seien, und wie sie zu denken vermögen, muß er ein für allemal zu dem viel schwerer abzugebenden Wahrspruch sich entschließen: „Ignorabimus“.
(E. du Bois-Reymond. Über die Grenzen des Naturerkennens, 1872, Seite 464)

http://upload.wikimedia.org/wikipedia/commons/thumb/c/cb/Bois-Reymond.jpg/220px-Bois-Reymond.jpg

The 7 World Riddles (7 Welträtsel)

Was ist Materie und Kraft? (*)
Woher kommt der Ursprung der Bewegung? (*)
Woher kommt das erste Leben?
Woher stammt der Zweck in der Natur?
Woher stammt die bewusste Empfindung in den unbewussten Nerven? (*)
Woher kommt das vernünftige Denken und die Sprache?
Woher stammt der „freie", sich zum Guten verpflichtet fühlende Wille? (*)

(*) transzendent

Counterarguments by David Hilbert (1900)

http://de.wikipedia.org/wiki/David_Hilbert

Diese Überzeugung von der Lösbarkeit eines jeden mathematischen Problems ist uns ein kräftiger Ansporn während der Arbeit; wir haben in uns den steten Zuruf: Da ist das Problem, suche die Lösung. Du kannst sie durch reines Denken finden; denn **in der Mathematik gibt es kein Ignorabimus.** [20]

„Hilbert plädiert damit für einen Optimismus in der Forschung, der selbstgesetzte Beschränkungen des Denkens ablehnt. Das Motto findet sich auch auf seinem Grabstein:

Wir müssen wissen. Wir werden wissen.“

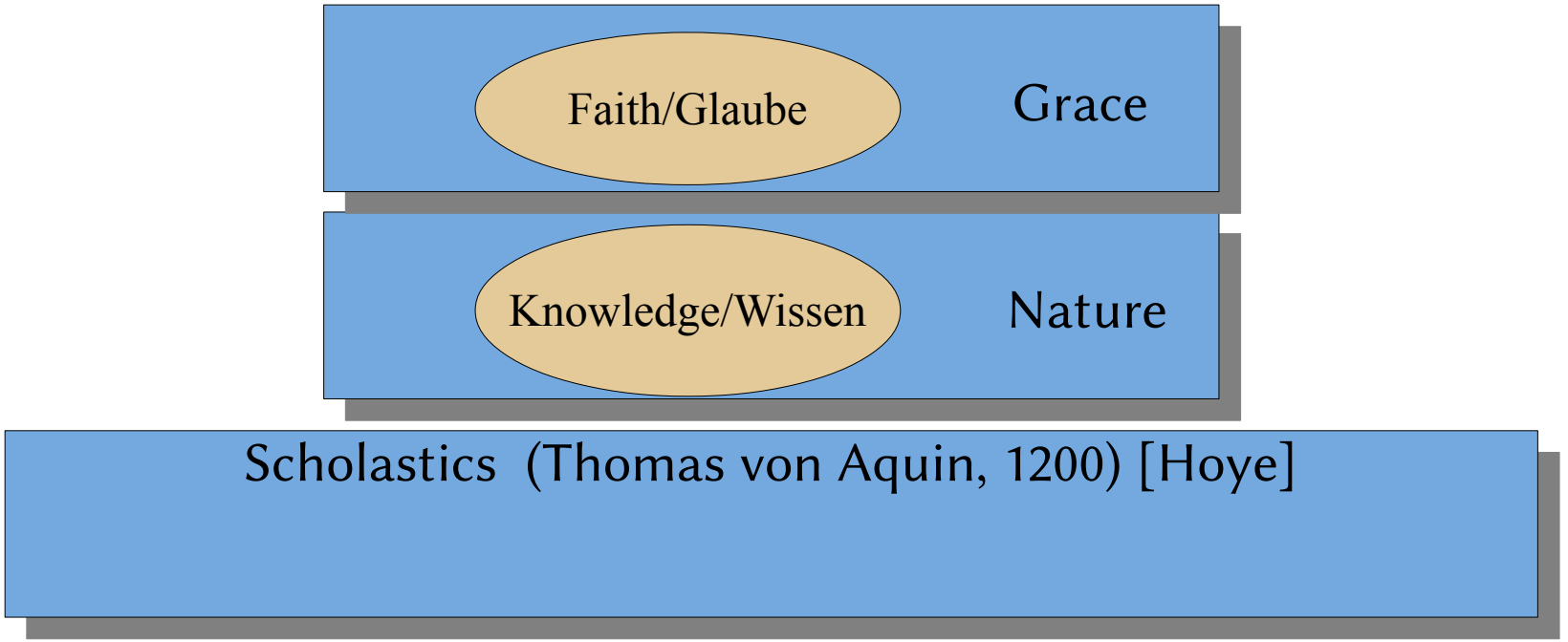
„Das ist es aber, was ich verlange: es soll in mathematischen Angelegenheiten prinzipiell keine Zweifel, es soll keine Halbwahrheiten und auch nicht Wahrheiten von prinzipiell verschiedener Art geben können

Das Ziel, die Mathematik sicher zu begründen, ist auch das meinige; ich möchte der Mathematik den alten Ruf der unanfechtbaren Wahrheit, der ihr durch die Paradoxien der Mengenlehre verlorenzugehen scheint, wiederherstellen; aber ich glaube, dass dies bei voller Erhaltung ihres Besitzstandes möglich ist.”

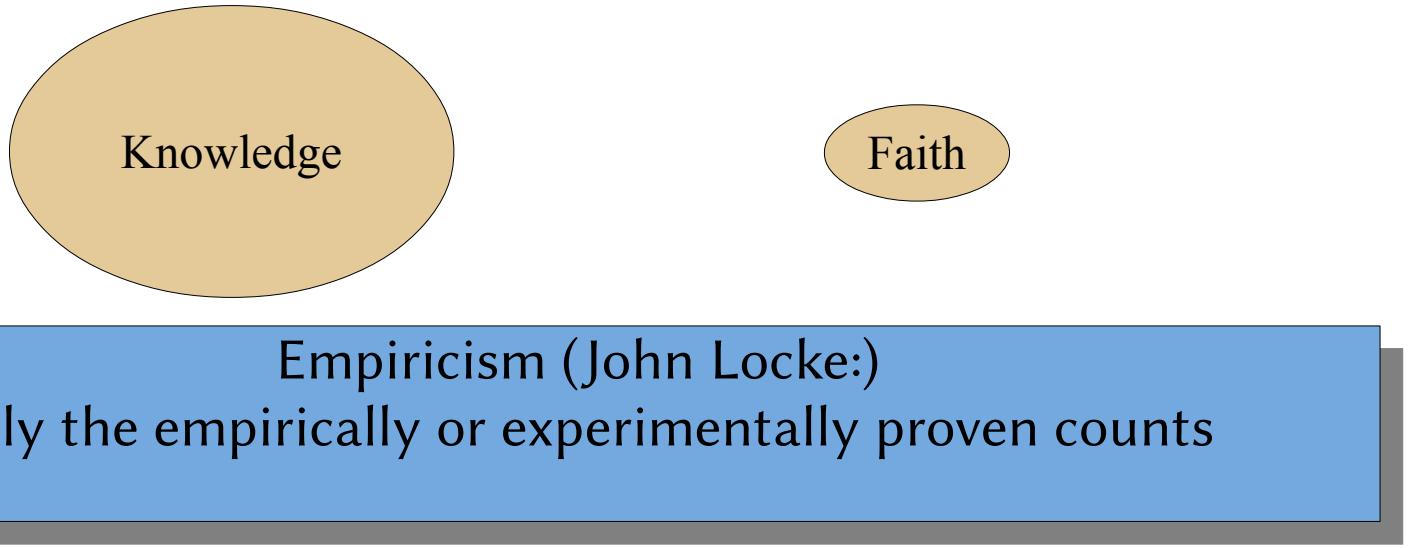
Mathematische Probleme – Vortrag, gehalten auf dem internationalen Mathematiker-Kongreß zu Paris 1900.

Traditional Models of the Relationship between Knowledge and Faith: Scholastics

- Aquinus distinguished knowledge by ratio and knowledge by revelation (faith).



Traditional Models of the Relationship between Knowledge and Faith: Empiricism



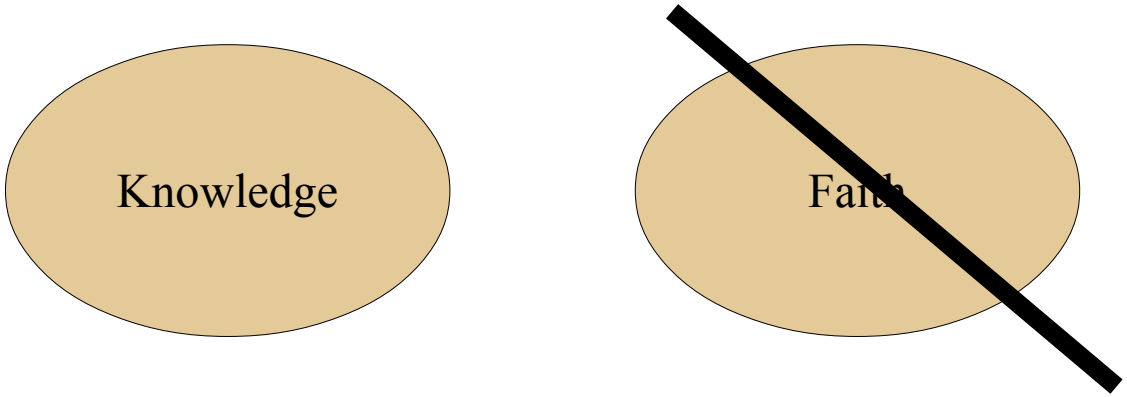
Empiricism (Empirism) is a theory of knowledge that asserts that knowledge comes only or primarily from sensory experience.

One of several views of epistemology, the study of human knowledge, along with rationalism, idealism, and historicism, empiricism emphasizes the role of experience and evidence, especially sensory perception, in the formation of ideas, over the notion of innate ideas or traditions; empiricists may argue however that traditions (or customs) arise due to relations of previous sense experiences.

http://en.wikipedia.org/wiki/Empirism

Traditional Models of the Relationship between Knowledge and Faith: Rationalism

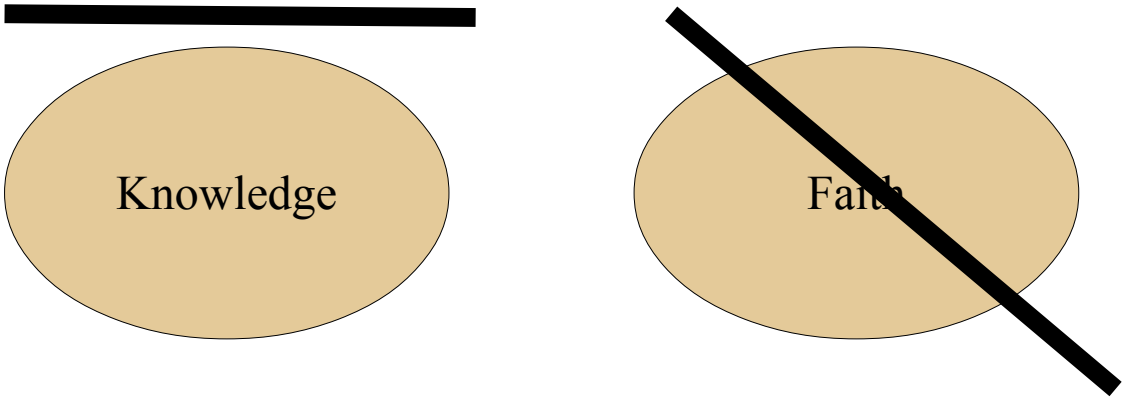
- http://en.wikipedia.org/wiki/Rationalism
- .. rationalism is "any view appealing to reason as a source of knowledge or justification." In more technical terms, it is a method or a theory "in which the criterion of the truth is not sensory but intellectual and deductive."
- Different degrees of emphasis on this method or theory lead to a range of rationalist standpoints, from
  - the moderate position "that reason has precedence over other ways of acquiring knowledge"
  - to the more extreme position that reason is "the unique path to knowledge."



Rationalism (Descartes a.m.m.):
only the logically proven counts

Traditional Models of the Relationship between Knowledge and Faith: "Ignorabimus" Rationalism

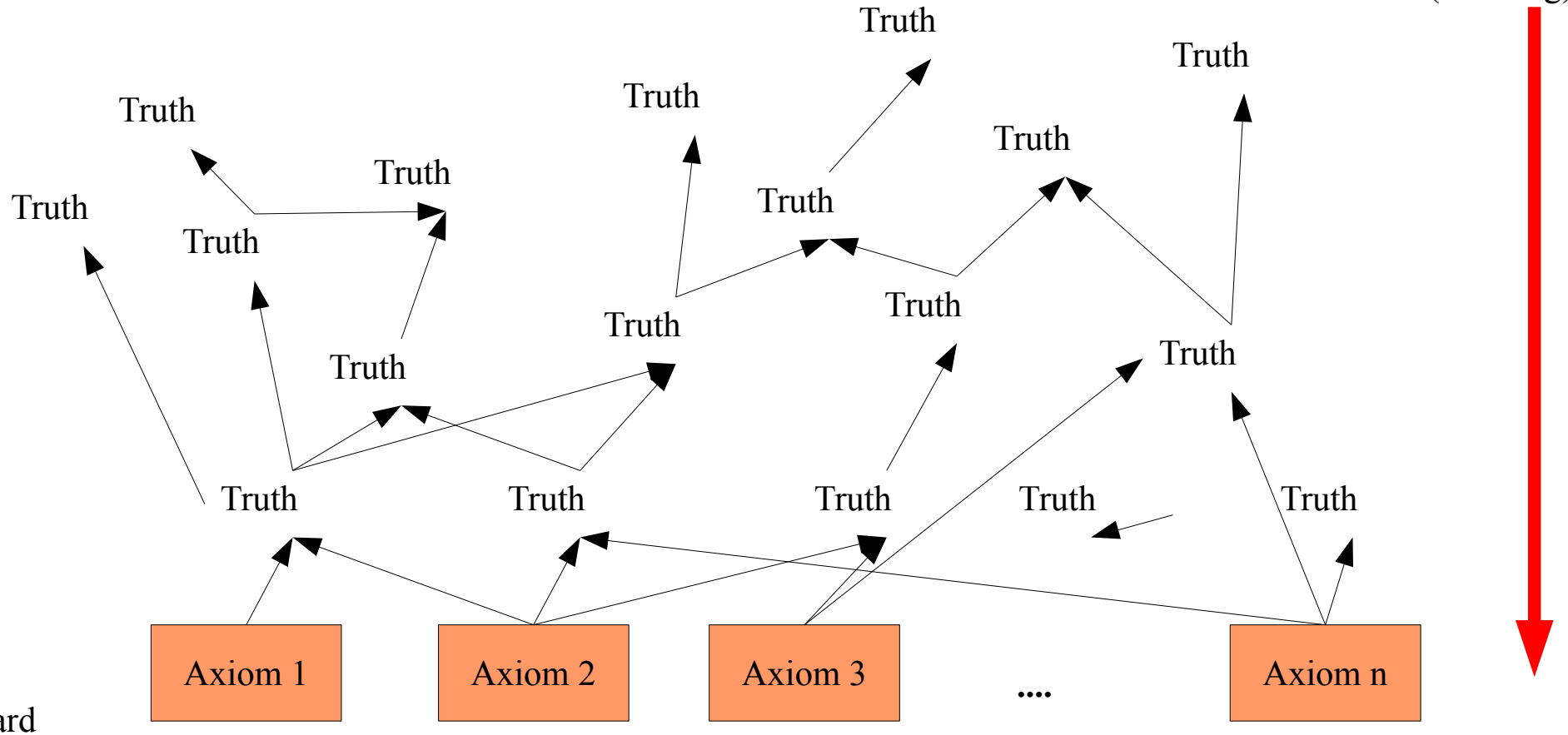
- was attacked by Hilbert, but confirmed by Gödel



Ignorabimus rationalism (du Bois-Reymond)
mechanistic world model, but limits of knowledge

Ignorabimus-Rationalism: Formal Science is Based on Unproven Axioms

- Since the 19th century, mathematics knows that without unproven axioms, thinking is not possible (axiomatic thinking)
- Hilbert's famous problem was to axiomatize mathematics

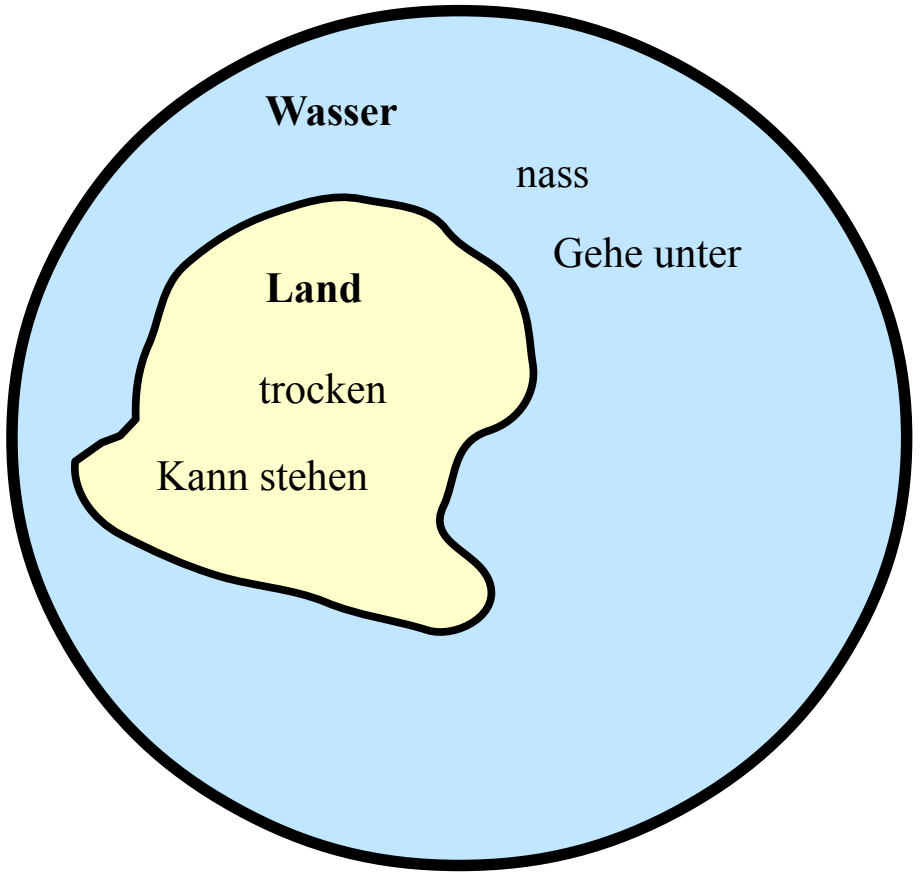


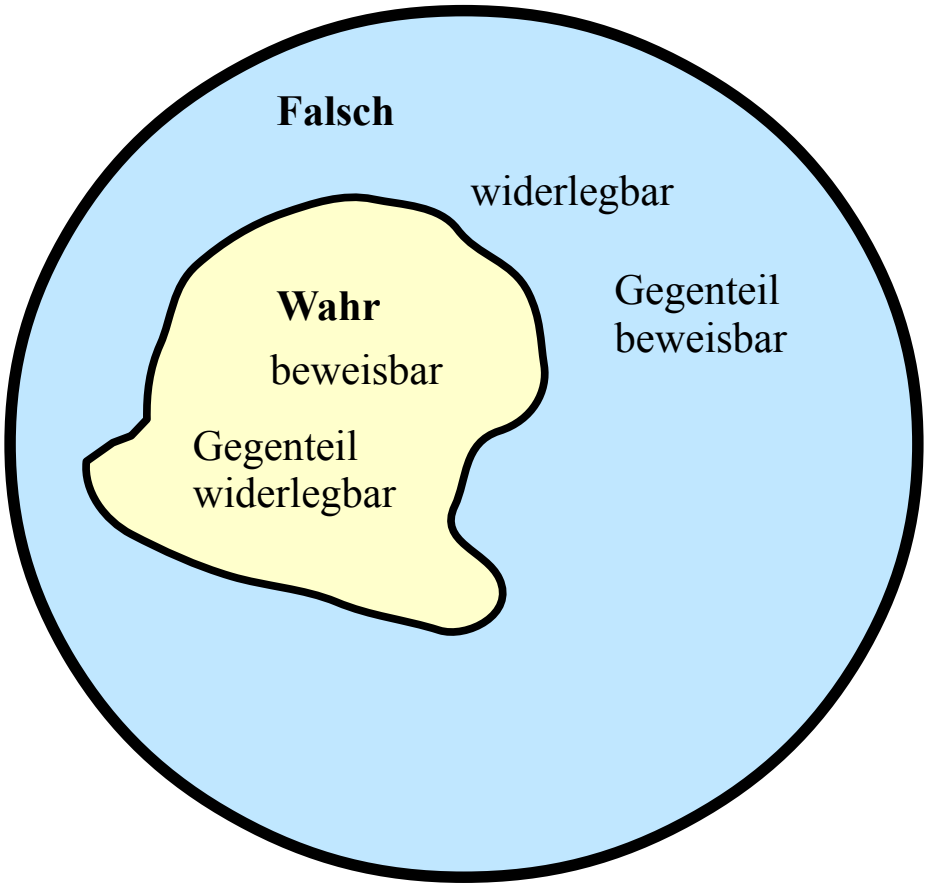
Axioms in Science

- Knowledge relies on proof by reasoning, experiment or empirics. But proofs rely on axioms
- Well-founded assumptions, Certitude and Faith means to assume some *more* unproven axioms

I do not define time, space, place, and motion, as being well known to all.
Isaac Newton

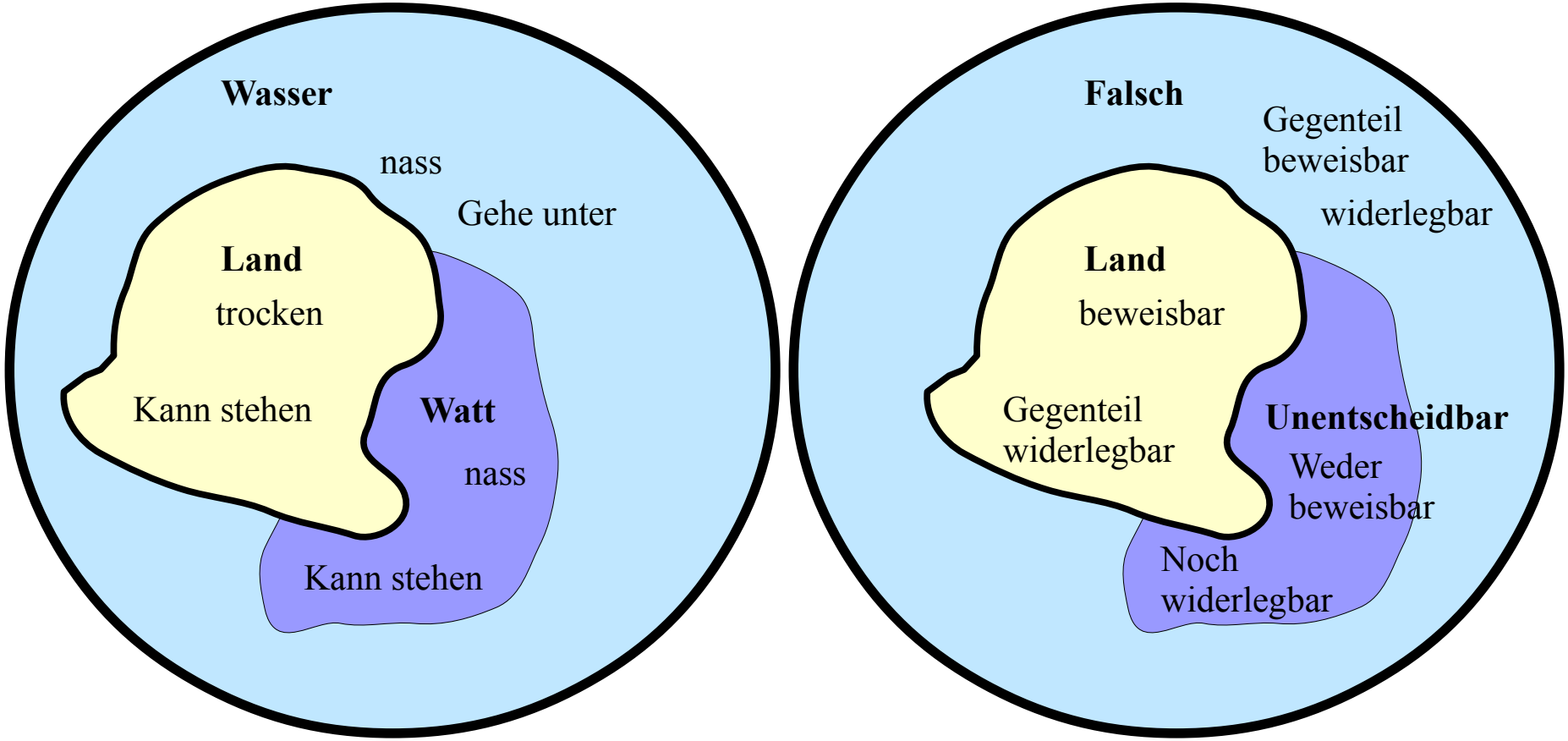
Before 1930 and Gödel: Everything is Decidable





After 1930: Undecidable Problems

- There are limits to the objectively provable knowledge (Gödel's Unvollständigkeitssatz 1933)
- du Bois-Reymond was right, not Hilbert!



- Translation of natural languages
- Covering infinite planes with tiling pati
- Terminiation of programs
- Second order logics (the truth machine)

Limits of Exact Science

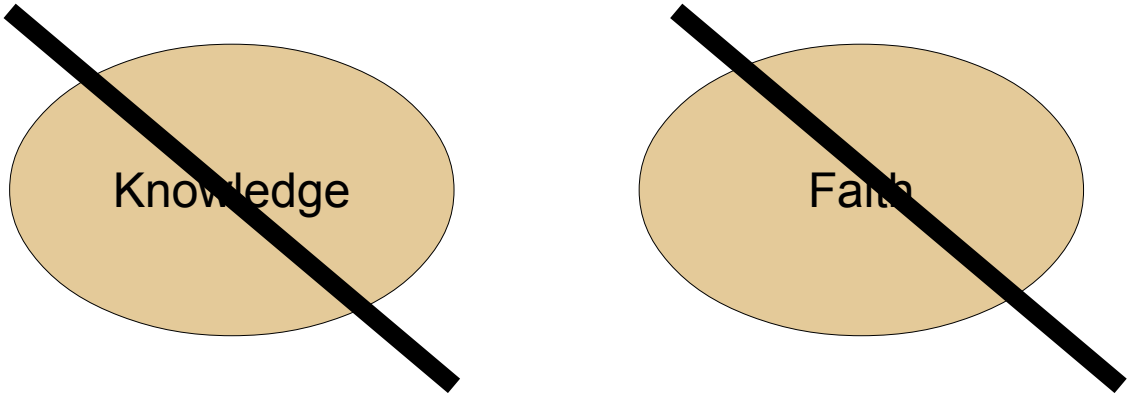
20th century has found out a lot of limits of exact science and rationalism (axiomatic thinking, decidability, falsificationalism etc.).

Science has not buried thinking about Transcendence, Faith, and Religion.

People should distinguish between the different types of science and knowledge. Of course, blind faith is no option, but blind rationalism is neither...

Traditional Models of the Relationship between Knowledge and Faith: Critical Rationalism

- "Falsificationism" philosophy of science (Wissenschaftstheorie) according to Karl Popper (critical rationalism)
  - Science never finds the full truth, but works with models
  - Models are idealistic abstractions of reality
  - Science falsifies models, i.e., approaches the truth step by step
  - Objective knowledge is impossible, can only be approached, i.e., is model-based
  - Instead of objective knowledge, well-founded assumptions are possible



Critical rationalism (kritischer Rationalismus, Falsifikationsimus, Popper)
Models are being falsified, idealistic research, easy to become agnostic, because practical problems are hard to prove

A.1.2 The Influence of Value Systems

- Science produces data and information. Knowledge and wisdom are gained by interpretation
- The reasons are mostly **subjective** and depend on
  - The past of the person (receiver): experience, crises, insight about oneself
  - The nature of the sender of some information: reports of trustworthy people and eye whitnesses
  - The state of the receiver: personal goals, hope, values, transcendency
  - The context of some information which is sent
- Scientific results (data, information) is interpreted by human beings to become knowledge, answering questions
- Scientific knowledge has limits

Interpretation, Value Systems, and World Models

- Thesis: Science is conducted in the context of the *value system* of the researcher
  - the researcher interprets the information, answering questions about his own state and the context, and thereby produces knowledge
  - The value system also forms the ethics and wisdom of science
  - Ex.: Nazi doctors didn't care about mistreated Jews because they considered them to be Untermenschen
- The value system of a researcher is determined by his *world model (Weltbild*) of God, Man, and Nature
  - Weltbild = Gottesbild + Menschenbild + Umweltbild
  - Motivation: Problem, Ziele, Nutzen
  - Das Wahre, Edle, Gute: Genuß, Schönheit, Kultur, Bildung
- In the 20th century in the Western Hemisphere, world models have been humanistic – christian – atheistic – heathen – social-darwinistic - sociologic
  - Also heathen religion played a role (Nazis)
  - and the sociology of communistic class fight

Examples For Value-Based Science (Christians)

- Thesis: also Natural Science is conducted under a value system and a world model
- Isaac Newton:
  - It is the perfection of God's works that they are all done with the greatest simplicity. He is the God of order and not of confusion.
  - Truth is ever to be found in simplicity, and not in the multiplicity and confusion of things.
  - God created everything by number, weight and measure.
- Galileo Galilei:
  - I do not feel obliged to believe that the same God who has endowed us with senses, reason, and intellect has intended us to forgo their use and by some other means to give us knowledge which we can attain by them.
  - (see more about the Christianity of Galilei in [Sova-Galileo]

Examples For Value-Based Science (Atheists)

- Thesis: also Natural Science is conducted under a value system and a world model
- Richard Dawkins, a strong rationalist [wikiquote]
- It is often said, mainly by the 'no-contests', that although there is no positive evidence for the existence of God, nor is there evidence against his existence. So it is best to keep an open mind and be agnostic. At first sight that seems an unassailable position, at least in the weak sense of Pascal's wager. But on second thoughts it seems a cop-out, because the same could be said of Father Christmas and tooth fairies. There may be fairies at the bottom of the garden. There is no evidence for it, but you can't prove that there aren't any, so shouldn't we be agnostic with respect to fairies?
  - Speech at the Edinburgh International Science Festival, 1992-04-15. Frequently misattributed to The God Delusion. In "EDITORIAL: A scientist's case against God". The Independent (London): p. 17. April 20, 1992. and Paul Gomberg (2011-05-27). What Should I Believe?: Philosophical Essays for Critical Thinking. Broadview Press.
- The total amount of suffering per year in the natural world is beyond all decent contemplation. During the minute that it takes me to compose this sentence, thousands of animals are being eaten alive, many others are running for their lives, whimpering with fear, others are slowly being devoured from within by rasping parasites, thousands of all kinds are dying of starvation, thirst, and disease. It must be so. If there ever is a time of plenty, this very fact will automatically lead to an increase in the population until the natural state of starvation and misery is restored. In a universe of electrons and selfish genes, blind physical forces and genetic replication, some people are going to get hurt, other people are going to get lucky, and you won't find any rhyme or reason in it, nor any justice. The universe that we observe has precisely the properties we should expect if there is, at bottom, no design, no purpose, no evil, no good, nothing but pitiless indifference.
  - "God's Utility Function", Scientific American: 85, November 1995, ISSN 0036-8733

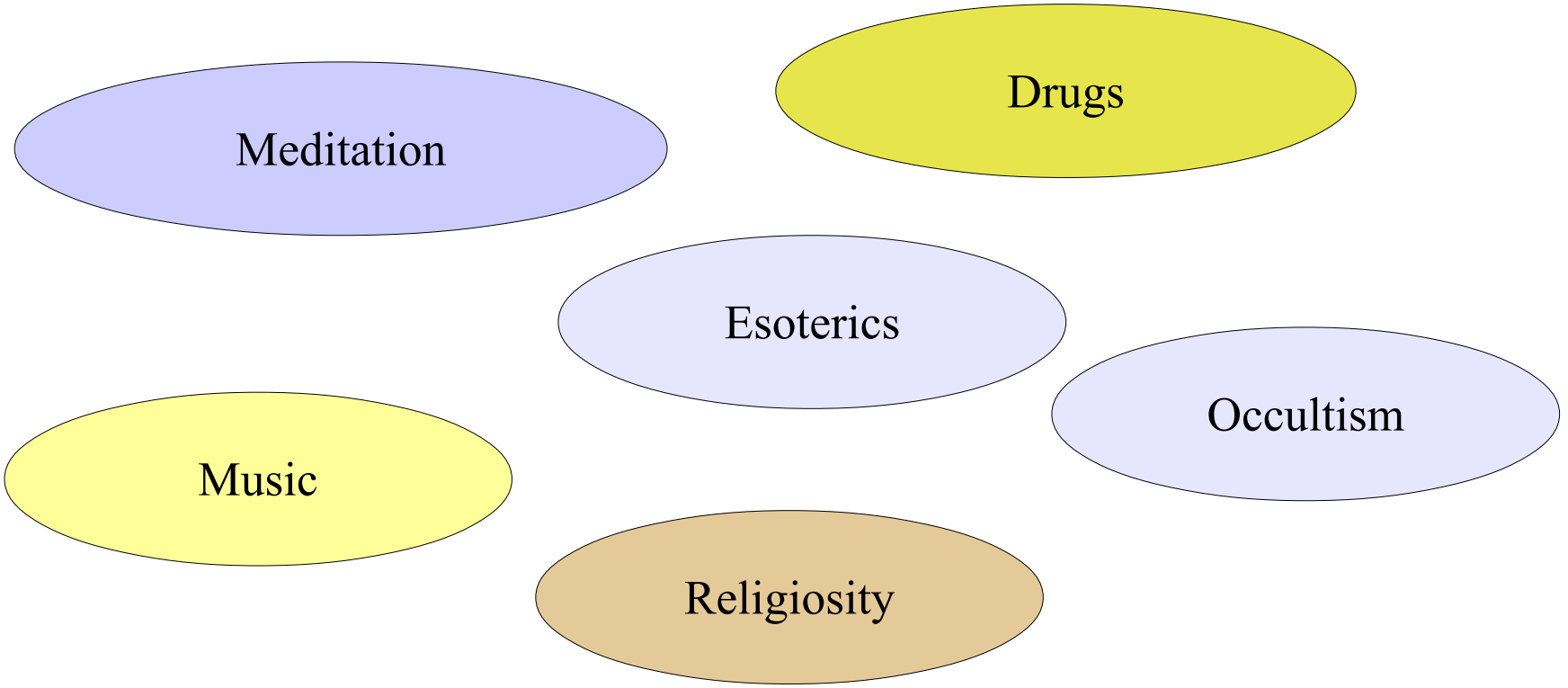
- Jacques Monod, nobel laureate. http://todayinsci.com/M/Monod_Jacques/MonodJacques-Quotations.htm
- The scientific attitude implies—the postulate of objectivity—that is to say, the fundamental postulate that there is no plan; that there is no intention in the universe.
  - Quoted in Geraldine O. Browning (ed). Et al.,Teilhard de Chardin: in Quest of the Perfection of Man (1972), p119.
- Chance alone is at the source of every innovaton, of all creation in the biosphere. Pure chance, only chance, absolute but blind liberty is at the root of the prodigious edifice that is evolution... It today is the sole conceivable hypothesis, the only one that squares with observed and tested fact.
  - Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology (1972), 112-113. In Holmes Rolston Genes, Genesis, and God (1999), p17.
- One of the great problems of philosophy, is the relationship between the realm of knowledge and the realm of values. Knowledge is what is; values are what ought to be. I would say that all traditional philosophies up to and including Marxism have tried to derive the 'ought' from the 'is.' My point of view is that this is impossible, this is a farce.
  - Quoted in John C. Hess, 'French Nobel Biologist Says World Based On Chance', New York Times (15 Mar 1971), p6.
- "Man at last knows he is alone in the unfeeling immensity of the universe, out of which he has emerged only by chance. His destiny is nowhere spelled out, nor is his duty. The kingdom above or the darkness below; it is for him to choose", 1971 [wikipedia entry]

Value Systems of Famous Engineers and Technical Scientists

- Poverty and laziness are a strong motivation for technical science
- John Harrison invented his H-3 clock because the Royal Society had put out a price of 10000 pounds for a precise ship clock.
  - Even after the clock proved to fulfil the criteria, the Royal Society changed the success criteria, and he fought for almost his entire life to get acknowledged and to get the reward [Sobel Longitude]
- Thomas A. Edison was driven by economic reasons: "Was soll ich forschen, wenn ich es nicht verkaufen kann"
  - Edison made more than 10000 light bulb variants before he found the right technique

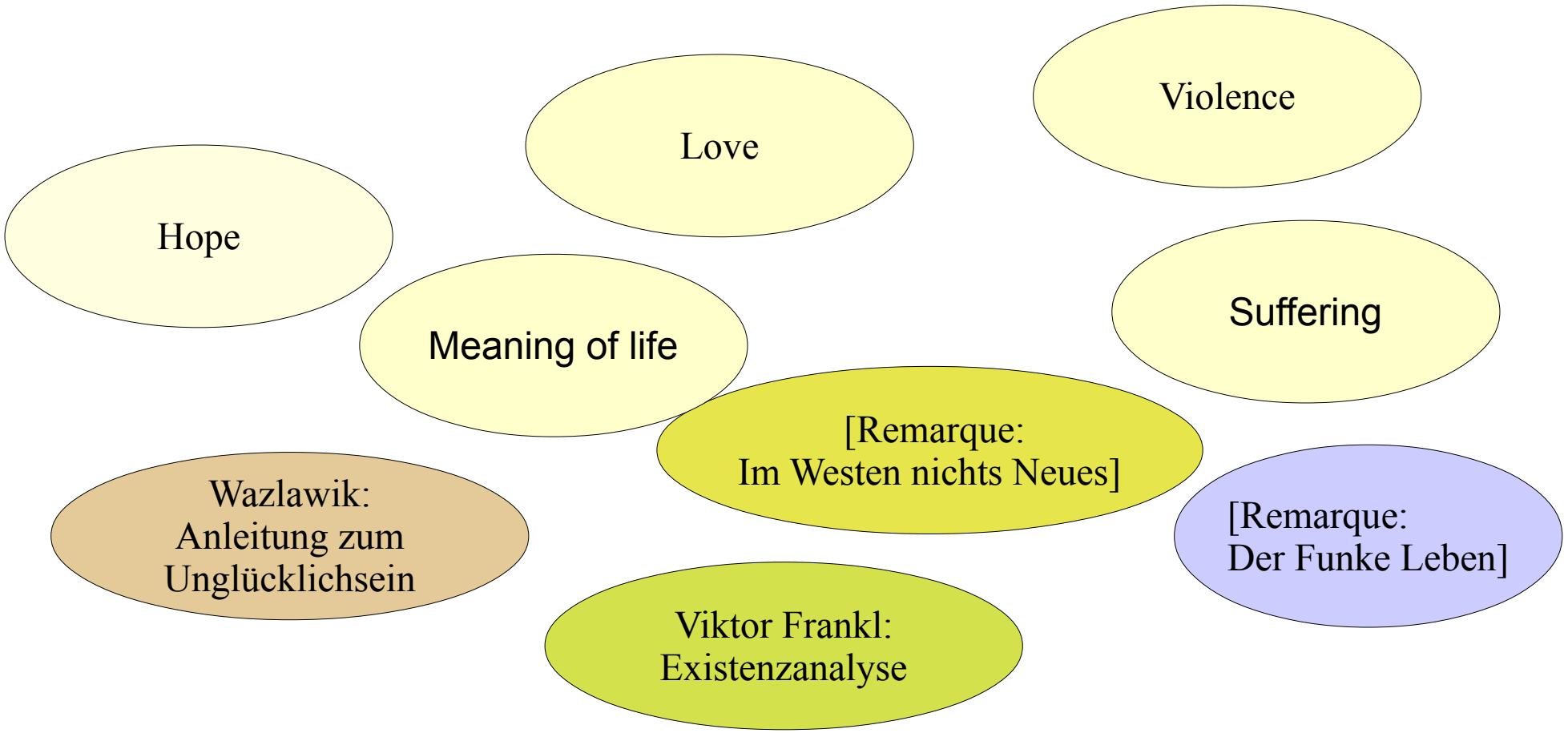
A.1.3 The Problem of Transcendence

- Not all humans have become scientists to get knowledge. This was the dream of Scienicism
- Clearly, scientists don't know everything.
- Clearly, humans long for transcending, i.e., to meet the invisible things (Bewusstseinserweiterung, Transzendenz), and use many other things to "know"



Questions for Transcendence

- Another strong motivation to assume limits of knowledge by science are the questions about how to transcend (leave this world and meet the invisible)



Summary

Knowledge can be created by different forms of science, but also by trust and subjective forms of „reasonable" evidence.

Exact science has limits (ignorabimus) and relies on unproven axioms.

Knowledge from scientific data and information is gained by interpretation under a value system and a world model of the resarcher.

Probably, science cannot answer our questions for transcendency.

Technical science can lead to solved problems, but needs to be embedded into a value system to be employed wisely.