Research and How it Works

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What is Research?

- Nibble on the tree of knowledge
- Driving force: human curiosity
Knowledge Gain

- Observations, measurements, trials
- Axioms, hypotheses, models
- Validation, verification, falsification
  - Proof (theoretical sciences)
  - Experiment (applied sciences), Empirical study, survey (social sciences)
  - Computational Sciences
  - Data Science
Research Aspects (1)

- Objectifiable, rational
- Reproducible, verifiable
- Principle of causality
- Reductionism - holism
- Paradigm shift
Spurious Correlations

US spending on science, space, and technology correlates with Suicides by hanging, strangulation and suffocation

![Graph showing the correlation between US spending on science, space, and technology and suicides by hanging, strangulation, and suffocation.](http://www.tylervigen.com/)

**Correlation:** 0.992082

**Sources:** US OMB & CDC, tylervigen.com

Permalink - Mark as Interesting (5,147) - Not Interesting (2,370)
Research Aspects (2)

- Epistemology
- Society and Science
  - Scientism
  - Anti-scientism
- Science – research - development
- Basic research – applied research
- Research is very costly (even more costly is not doing research)
**Research Aspects (3)**

- Very strong differentiation

- Exponential data growth
Research Paradigms

- Experimental sciences (observations, experiments)

- Theoretical sciences (modelling to describe and explain natural phenomena)

- Scientific computing (computer simulation of mathematical models)

- Data science (big data, smart data, machine learning)
Where does Research happen?

- **Universities:** “Unity of Teaching and Research” [https://www.bmbwf.gv.at/]
- Extra-mural research institutes
  - IST Austria, AIT, Joanneum Research, Oefai
- Academy of sciences
- Public – private research partnerships
  - K+ Centres (VRVis, http://www.vrvis.at/)
- Commercial companies
  - Typically in large companies
  - (Research and) development
Research at Universities

- What is a university teacher doing?
  - He/she is teaching (4 - 12 weekly hours each term)
  - He/she is doing administrative work (study curriculum, ...)

- What is he/she doing during the breaks?
  - He/she is going on vacation

And then he/she is doing research
Research Groups

- Institute subdivided into several research groups
- Joint research interests
- Members of a research group
  - University teachers
  - Research associates, PhD students
  - Master students, Bachelor students, interested students
- Carrying out research projects
Research Projects (1)

- Single projects – joint projects
- Problem, goal, approach, outcome, costs
- Processing in several phases (milestones)
- In each phase defined
  - Desired goals and results
  - Actions, implementation measures
  - Evaluation
  - Duration
Vis-Group: Funding and Projects

General Hospital Vienna

FWF

FFG

imagination at work

The Scripps Research Institute

Allen Institute for Cell Science

Inria

AIT Austrian Institute of Technology

King Abdullah University of Science and Technology
Research Career

- Professional career in science
  - Tutor (teaching/research assistant)
  - Bachelor thesis, Masters thesis
  - Doctorate (university assistant, research assistant, ...)
  - PostDoc
  - Habilitation (tenured position), Professorship

- Qualities of a good scientist
  - Curiosity (why, why, why, ...)
  - Creativity
  - Excellent command of tools
  - Analytical thinking
  - Perseverance, tenacity, thoroughness, frustration tolerance

Creativ
Competent
Cooperative
Research Projects - Milestones

- Project start
- State-of-the-art survey
- Formulation of ideas and goals
- Implementation, realization
- Testing, evaluation
- Publishing (write a scientific paper)
- Project end with debriefing
CT - Angiography
Research Results

- Bachelor theses
- Master theses
- PhD theses
- Publications (https://www.cg.tuwien.ac.at/research/publications/)
  - At conferences
  - In scientific journals
- Software prototypes
- Patents, licenses
- Spin-off companies
Research Groups (1)

- Internal Communication
  - Individual meetings
  - Organisational meeting
  - Scientific meeting
  - Colloquy cycle
  - Yearly closed meetings
  - Social interaction
Research Groups (2)

- External Communication
  - Colloquy cycle, guest lecturer
  - Guest researcher
  - External research stays
  - Conference attendance
  - Publications (papers, posters)
    - Scientific
    - Popular science
  - Trade fairs
- Organized by scientific associations
- Local organizers
- Conference chair, program committee
- Call-for-papers
- Submission of scientific papers (technical reports)
- Peer reviewing
- Conference attendance, giving a talk
- Article published in conference proceedings
Publications - Journals

- Published by commercial publisher or scientific association
- Editor-in-chief, editorial board
- Submission of scientific papers (technical reports)
- Peer reviewing
- Major revision with second review cycle
- Article published in journal
- Duration: half a year and longer
Scientific Associations

- Advancement of scientific area, members
- Ethical guidelines
- Publishing of journals
- Organization of scientific events
- Examples of scientific associations
  - OCG (http://www.ocg.at/)
  - GI (http://www.gi-ev.de/)
  - Eurographics (http://www.eg.org/)
  - IEEE (http://www.ieee.org/)
  - ACM (http://www.acm.org/)
Journals on Academic Establishment

- Austrian University Journal

- German University Journal
Research Activities - Evaluation

- #Publications
- #Patents
- #Talks
- Acquired research fundings
- #PhD, #Master, #Bachelor students
- Member in scientific associations
- Member in program committees
- Member in editorial boards
- #citations
  - Science Citation Index
  - http://scholar.google.com/
  - http://citeseer.ist.psu.edu/
  - https://www.scopus.com/home.uri
  - http://www.vs.inf.ethz.ch/publ/slides/Citation-Index- Unsinn.pdf

[https://en.wikipedia.org/wiki/H-index]
Research Funding

- University, science funds, company funding
- Science funds
  - FWF – basic research fund (http://www.fwf.ac.at/)
  - FFG – applied research fund (http://www.ffg.at/)
- EU – funding programs
  - Horizon Europe (2021-2027)
  - ERC grants
How to Run a Successful Research Group?

https://www.cg.tuwien.ac.at/research/publications/2021/wu-2021-vi/
Unity of teaching and research

Scientific topics dealt with in

- Proseminars, Seminars
- Programming assignments, computer science projects
- Bachelor thesis
- Master thesis
- PhD thesis

Research is fascinating
Join in nibbling!
Further References

- https://www.cg.tuwien.ac.at/research/publications/2021/Groeller_2021_BVM/
- https://www.cg.tuwien.ac.at/research/publications/2021/wu-2021-vi/
- http://er.educause.edu/articles/2012/6/scientific-research-how-many-paradigms