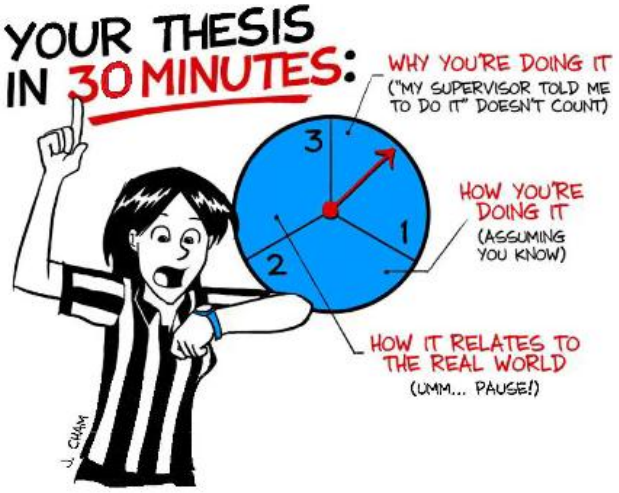
# About Scientific Writing (Mek3200, Mat2000, Stk-Mat2011)

Kent-Andre Mardal

# Overview of this lecture

- Scientific writing is different from other types of writing – it is all about precise and balanced content
- Today we will discuss how scientific writing is typically evaluated (master thesis evaluation)
- Then, try to come up with an algorithm for writing a first draft



# Sensor guidance on censorship of master assignments

The sensor assesses for each point the extent to which the candidate has achieved these goals:

1. Professional anchoring
2. Theoretical insight
3. Target description
4. Skill Level
5. The work
6. Analysis and discussion
7. Critical reflection
8. Own contribution / goal achievement
9. Structure
11. Form


"I almost wish I hadn't
gone down that rabbit-hole
—and yet—and yet—
it's rather curious, you know,

# Language

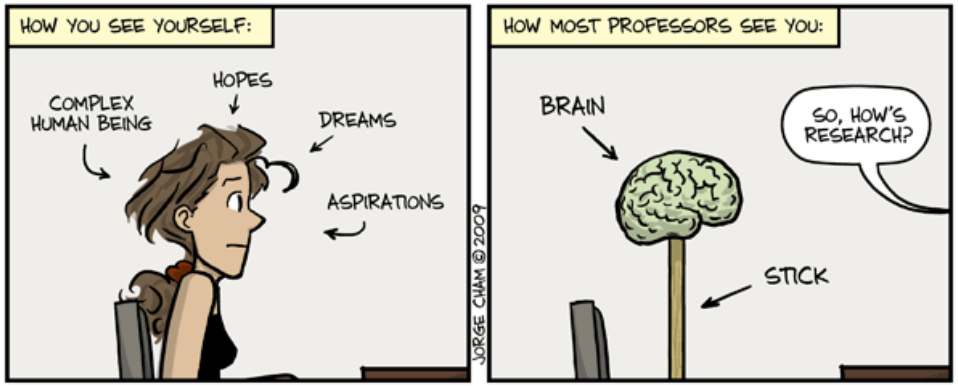
Can the candidate present problem and results with the necessary professional precision? Is it highly readable with high quality in the language used?

(Usually not a problem mostly because fellow students help with cleaning up the language)

# Skill level

Do candidates apply relevant methods and use them in their own work in an appropriate and integrated manner?

(Usually not a problem because the supervisor has a pretty good idea of appropriate methods)



# Effort

Does the work show creativity and / or contribute to innovation / innovation? Does the work give an impression of being particularly extensive? How is the quality and importance of new knowledge / new results generated in the work assessed?

(usually the effort is substantial – don´t put too much weight on the innovative and creative parts)

# Professional anchoring

Is the theoretical and academic foundation well described so that the work is included in the field of international research?

(quite often a problem: to little time spent on reading to get an overview)

# Analysis and discussion

Is analysis, interpretation / synthesis and discussion professionally founded and justified and clearly linked to the issue? Is the discussion at a high academic level? Can the candidate apply his / her knowledge and skills in new areas and place the results in a larger context?

(quite often a problem: requires an overview)

# Critical reflection

Does the candidate give a reasonable assessment of the importance of the results? Is the candidate critical of different sources of information? Are uncertainties, such as method errors, measurement errors, and others considered and discussed? Are relevant academic, occupational and research ethical issues analyzed?

(quite often a problem: again how can one assess the importance and limitations of the work without an overview of the field)

# Preliminary conclusion

A lot of the criteria concern “your overview of the field”:

- anchoring
- analysis and discussion
- critical reflection


It is not sufficient to just read the few papers your supervisor hands out in the beginning

- Matt Might´s illustrated guide

Introduction

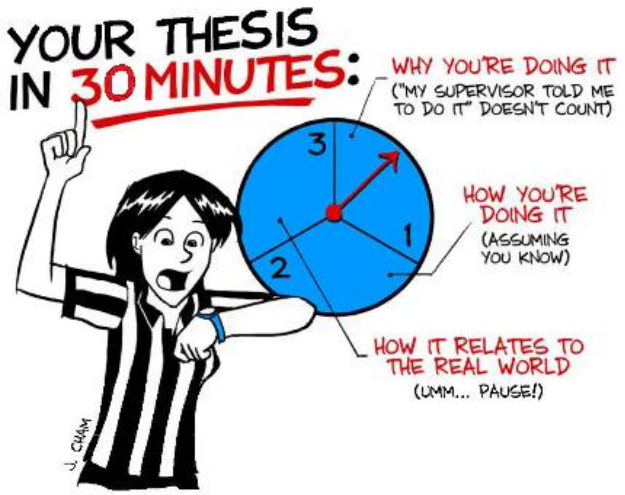
The problem, broad terms

What others have done

What you will do and how

The bulk of the thesis

- Preliminaries, notation
- Methodology
- Results




Discussion/Conclusion

Summary of what you have done

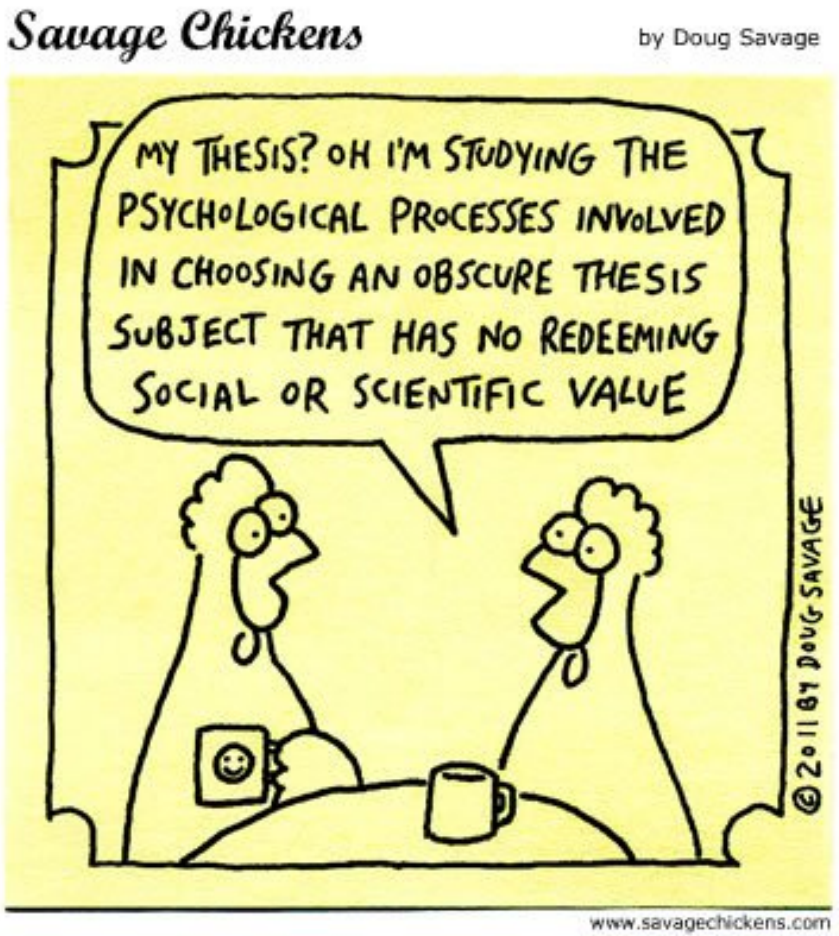
Limitations, weakness

What others have done

And significance

# Examples of introductions

-Big Picture / Why
-What others have done
-What you will do
-How you will do it



# Introduction

The Cerebrospinal Fluid (CSF) is a clear, colorless fluid occupying the space around the brain and spinal cord, namely the Spinal Subarachnoid Space (SSS). The CSF is produced in the cerebral ventricles in the brain, and pulsates through the SSS with nearly zero net velocity. Since the CSF surrounds the Central Nervous System (CNS), drugs are often distributed via the CSF. Due to large patient specific variations of the geometry in the SSS and the complexity of the flow in the CSF, it is a difficult task to predict and control the concentration of the drugs [15]. A poor measurement access in the SSS also restricts our knowledge of the spreading. The uncertainty of the uptake and spreading of the drugs may lead to an increased risk of complications. This is the motivation for developing numerical simulations where the input parameters are the patient-specific variables, and the output is the concentration of the drug. Such simulation could help to optimize the medical procedure and to improve the knowledge of the physiological dynamics.

Throughout the years, many studies have been done on the CSF dynamics both *in vivo*, *in vitro* and *in silco*. Studies using different MRI techniques to measure the CSF flow *in vivo* includes [4, 10, 41, 28]. Many of these studies are related to investigating CSF flow in patients with Chiari malformation. Experiments have been perfomed *in vitro* in e.g. [23, 22, 24] to map the CSF flow related to the the syringomyelia disorder. In recent years, researches have begun to apply Computational Fluid Dynamics (CFD) models to improve the knowledge of the CSF flow. Some studies [18, 21, 31] used simplified/idealized models of the SSS to simulate the CSF flow. The first study to include microstructure in the SSS was Stockman [32], where idealized models of NRDL and trebeculae were used with Lattice Boltzman simulations. Heidari Pahlavian et al. [11] and Tangen et al. [37] followed

Per Thomas Haga, Numerical simulations of advection-dominated scalar mixing with applications to spinal CSF flow and drug transport, 2015

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What others have done

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# Introduction

The coupling of viscous and porous flow is of fundamental importance in many geophysical processes and industrial applications, such as water flowing across soil, oil filtering through sand or rocks and groundwater flow. Within medical research this model can be used to simulate the blood flow in our circulatory system and the surrounding tissue. As blood transports oxygen and nutrients through the body, phenomenas such as sugar transportation to a tumor, drug delivery to arteries and passage of oxygen in the brain can be modeled. The mathematical simulations are often easier to conduct and less expensive than finding exact measures through e.g. advanced digital image processing or experiments, hence they provide an opportunity to obtain a better understanding of complicated natural processes. This can potentially lead to improvement of diagnosis and treatment of diseases or new and better engineering techniques. However, robust and efficient numerical algorithms for this type of flow are challenging because viscous and porous flow require different numerical strategies.

The flow is governed by the Stokes equations in the viscous domain and by Darcy's law in the porous domain, and is therefore commonly referred to as Darcy–Stokes flow. Darcy–Stokes flow is coupled at the interface $\Gamma$ between the two domains, introducing coupling conditions. The system is, as earlier

Ada Johanne Ellingsrud, Preconditioning unified mixed discretizations of coupled Darcy–Stokes flow, 2015

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Big picture, overview, math point of view

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Several researchers [2, 3, 4, 5] have suggested to use unstable element combinations along with stabilization techniques. The primary mot… such an approach is the advantage of flexibility when it comes t… finite elements. For example, it typically requires less computation… than using uniformly stable elements, as they often have more degrees of freedom. In addition, stabilization techniques enable better approximation of solutions which vary in character from one part of the domain to another. Burman et al. [3] develop a lower order method using $P_1 \times P_1$ elements in combination with an interior penalty technique. Badia et al. [2] follow Burmans approach, and apply the method with $P_1 \times DG_0$ elements. Rui et al. [4] use stabilized Crouzeix–Raviart elements. Karper et al. [6] suggest a discretization where the Taylor–Hood or the Mini element produce a stable scheme for the coupled problem. Mardal et al. [1] propose a new stable $H(\mathrm{div})$ conforming element that gives optimal order estimates in both regions. These relatively new elements have to the author's knowledge not yet been successfully implemented.

What others have done

We will consider the two formulations suggested by Karper et al. [6] f… Darcy–Stokes problem, that is, the $L^2$-formulation where the … ties are assumed to be in $L^2$ and the $H(\mathrm{div})$-formulation where … velocities are assumed to be in $H(\mathrm{div})$. The $L^2$-formulation will be … cretized using the uniformly stable Taylor-Hood [7] elements, as suggested in [6]. The $H(\mathrm{div})$-formulation will be discretized using the $H(\mathrm{div})$ conform-

What will be done and how

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# 1. Introduction

An aneurysm is an abnormal bulge of a blood vessel, which often occurs in arteries in the vicinity of the Circle of Willis, part of the brains blood supply. These cerebral aneurysms may grow and occasionally rupture, causing a serious condition called subarachnoid hemorrhage (stroke), i.e., bleeding in and around the brain. This condition often leads to serious brain damage or death[3,4]. Worldwide, there are about 10.5 cases per 100,000 person years of subarachnoid hemorrhage caused by aneurysm rupture[5].

In Section 2 the medical background of aneurysms and blood flow is outlined, and factors contributing to aneurysm development are presented. It is not known exactly what triggers aneurysms to initiate, grow and occasionally rupture. In an attempt to better our understanding of cerebral aneurysm development, numerical models may be used to simulate the blood flow and arteries in and around the Circle of Willis.

To model blood flow, one needs to solve the Navier-Stokes equations. These equations arise from the simple principles of conservation of energy, momentum and mass, and are truly magnificent in that they seem to model any fluid qualitatively correct. In Section 3, the Navier-Stokes equations are derived.

In this thesis, a Navier-Stokes solver has been modified from the project *nsbench*[1]. The implementation is done as described in Section 4, and the implementation is verified by comparing to exact solutions in Section 5. Throughout the text small code snippets are found to illustrate the implementation of problems discussed, and in Appendix A some larger sections of code can be found. All the source code, as well as animations of the simulations done can be found at `http://folk.uio.no/oyvinev/master`.

By using computer models to simulate the blood flow in arteries, much more information can be gathered than what physical experiments can provide. Both the spatial and temporal resolution of the simulations are far superior to any measurement methods currently available. In simulations, both the pressure and the velocity field is known at any point of the flow domain. These simulations can be done causing minimal disturbance to the patient, as only a digital 3D-image[2] of the area of interest is needed to perform simulations. This

Øyvind Evju, Sensitivity analysis of simulated blood flow in cerebral aneurysms, 2011

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Background with other works is here elsewhere (chap 2)

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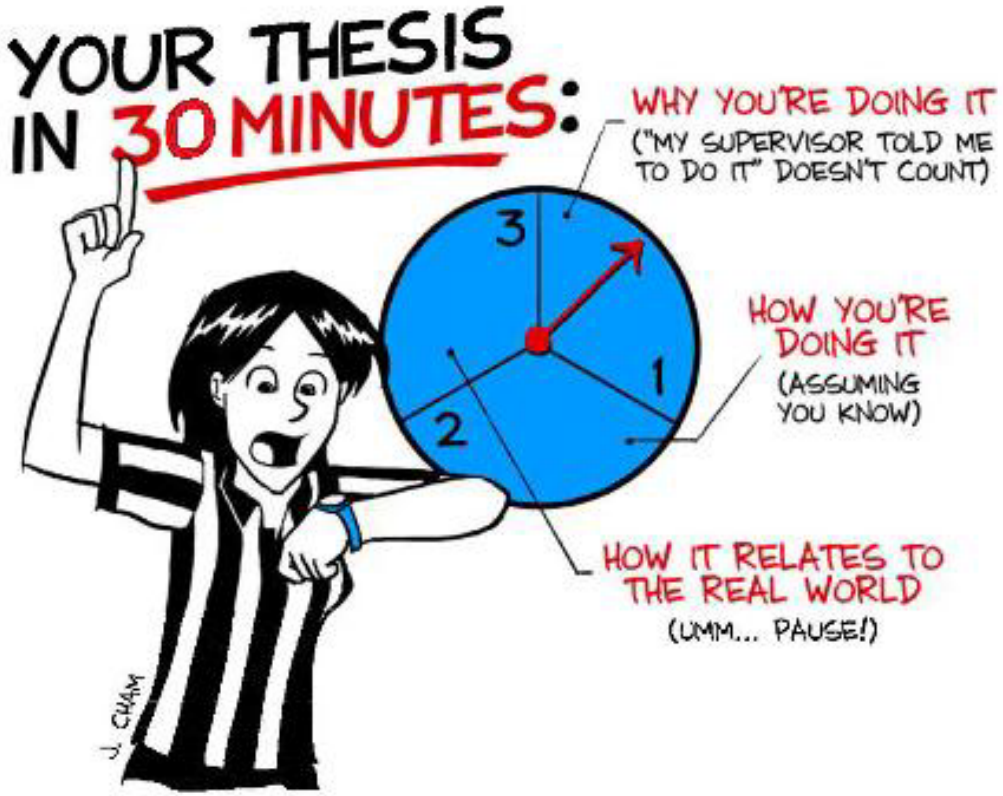
# Examples of some discussions/conclusions

-Summary of what has been done

-limitations, weakness

-how it relates to what others have done

-significance



## Conclusions

The conducted simulations show differences in flow characteristics of patient-specific Chiari I and normal models. Peak velocities, synchronous bidirectional flow and flux appear to have higher magnitudes in Chiari I models compared to the healthy models. In the upper levels of the anatomy, where the tonsils are, the Chiari I models tend to have a steeper pressure gradient than the volunteers. Postoperative patients' models are similar to those of Chiari patients' in both peak velocities and synchronous bidirectional flow. Differences in the duration of synchronous bidirectional flow are not apparent between the three groups. As no significant differences in tapering have been found, we cannot relate the effect of tapering to our results.

The CSF flow is complex in both Chiari and volunteer models. However, spatial and temporal flow variations are more apparent in Chiari I models. Jets occur in five of the Chiari models and in two of the healthy models, yet are larger, more frequent and have higher magnitudes in the Chiari group. Complex flow patterns and jets occur also in two of the postoperative patients.

Common velocity patterns for models with tonsillar herniations are apparent. Dominance of flow anterior-posterior to the cord appears to depend on the axial level of study. Generally, in tonsil-herniated models, higher velocity bands appear at foramen magnum (posterior to the cord), at C1 (anterior to the cord), at C3/C4 (posterior) and at C5/C6 (anterior). Peak velocities appear in one or several of these locations. For healthy models without sign of tonsils, the velocity patterns are less complex as the velocities increase progressively towards C5/C6.

Gabriela Rutkowska, Computational Fluid Dynamics in Patient-Specific Models of Normal and Chiari I Geometries, 2011

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Summary of findings

Gabriela Rutkowska, Computational Fluid Dynamics in Patient-Specific Models of Normal and Chiari I Geometries, 2011

**Concurrence with previous research**

Our report on higher peak velocities in Chiari-models compared to those of volunteers agrees with a majority of previous research (e.g. Shah et al. (2011), Hentschel et al. (2010b), Quigley et al. (2004), Haughton et al. (2003)). Further, the more diverse spatial and temporal variations observed in Chiari-models are in accordance with research by e.g. Quigley et al. (2004) who reported that peak systolic and diastolic velocities appear in the same regions in volunteers, while they emerge in distinct regions in Chiari patients. In our Chiari models, the repetitive change in flow domination posterior-anterior to the cord seems not to agree with previous examinations. E.g. Quigley et al. (2004) and Linge et al. (2011) observed higher velocities mainly in the anterior nodes. Observation of jets in the anterolateral locations in five of the Chiari patients corresponds to previous findings by e.g. Roldan et al. (2009), Quigley et al. (2004), Shah et al. (2011). However, the jets in our study have velocity magnitudes that vary during the cardiac cycle and they do not appear visible during the whole cycle.

Synchronous bidirectional flow found mainly along the side-boundaries in both our Chiari models and our normal models is in agreement with findings of Linge et al. (2010). However, we do not find any significant differences in the duration of synchronous bidirectional flow between the three studied groups.

The lack of MRI - data of postoperative patients prior to surgery makes it difficult to make conclusions on outcomes of the surgery. However, we observe that average peak velocities are higher in our postoperative models compared to our Chiari models. Previous studies of postoperative patients have shown that the peak velocities are not always reduced by the surgery. A study on 8 postoperative Chiari I patients conducted by Dolar et al. (2004) has shown overall reduction in peak velocities, however in 3 of the patients either the systolic or the diastolic peak velocity or both increased

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How the work is related to what others have done

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does not give an entirely realistic representation of the cardiac circle. However, testing an asymmetric pressure function on one of the models (Section 3.8) yields fairly equivalent results with respect to peak velocities, synchronous bidirectional flow and flux.

The sample size in this study is rather small, which may limit our statistical power to detect differences. Although we cannot base our conclusions on the t-test, its indications together with our analysis of the results yield fairly visible differences between our Chiari and healthy models. The patients studied are not a homogeneous group with respect to age or gender. Those factors may have an impact on the CSF velocities (e.g. Shah et al. (2011)) and would need further analysis.

The boundaries in our models are rigid, while the cord and tonsils are known to move and deform with the pulsating CSF. For a more realistic result, this could be changed in further research. However, it has been suggested that the boundaries' movement is relatively small compared to the dimensions of the cord (Levy, 1999).

**Significance**

The method presented in this study yields a noninvasive approach for verifiable measurement of the CSF velocities in real patients. Combined with (and adjusted according to) MRI-measurements it gives the advantage of studying the results globally or locally at a desired point in time in any chosen plane. During result-analysis, we notice that in measurements of peak velocities, velocity magnitudes may change significantly between locations that are within small distance from each other. Thus, using solely the MRI-measurements might give unrealistic impression of the CSF velocities in patients. E.g. in our model of patient no. 26, the computed peak systolic velocity was 37% higher than the single level MRI peak velocity measure-

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Limitations, weakness

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Why is this study important, quantification

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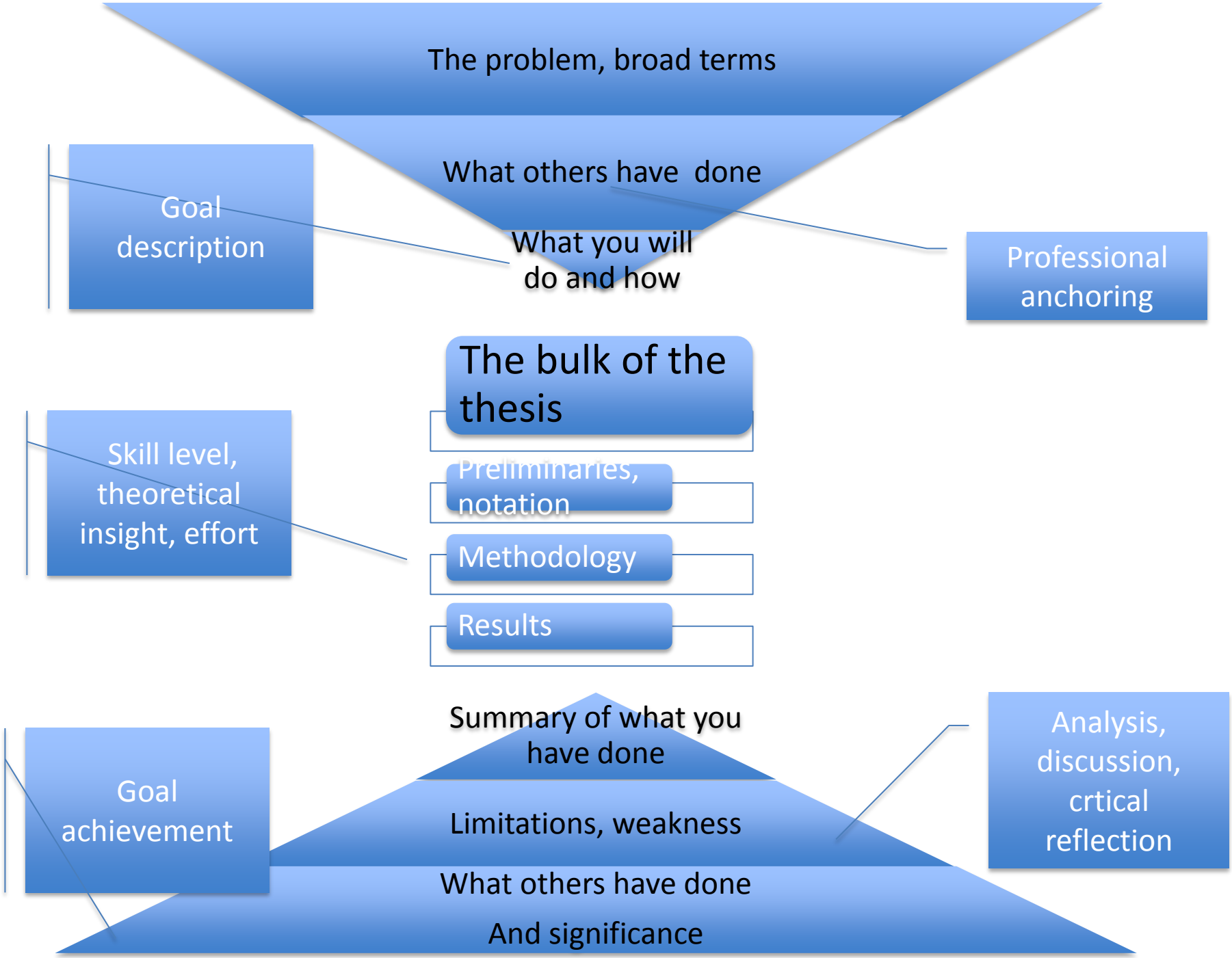

The problem, broad terms
What others have done
What you will do and how
Goal description
Professional anchoring
The bulk of the thesis
Skill level, theoretical insight, effort
Preliminaries, notation
Methodology
Results
Summary of what you have done
Limitations, weakness
What others have done
And significance
Goal achievement
Analysis, discussion, crtical reflection

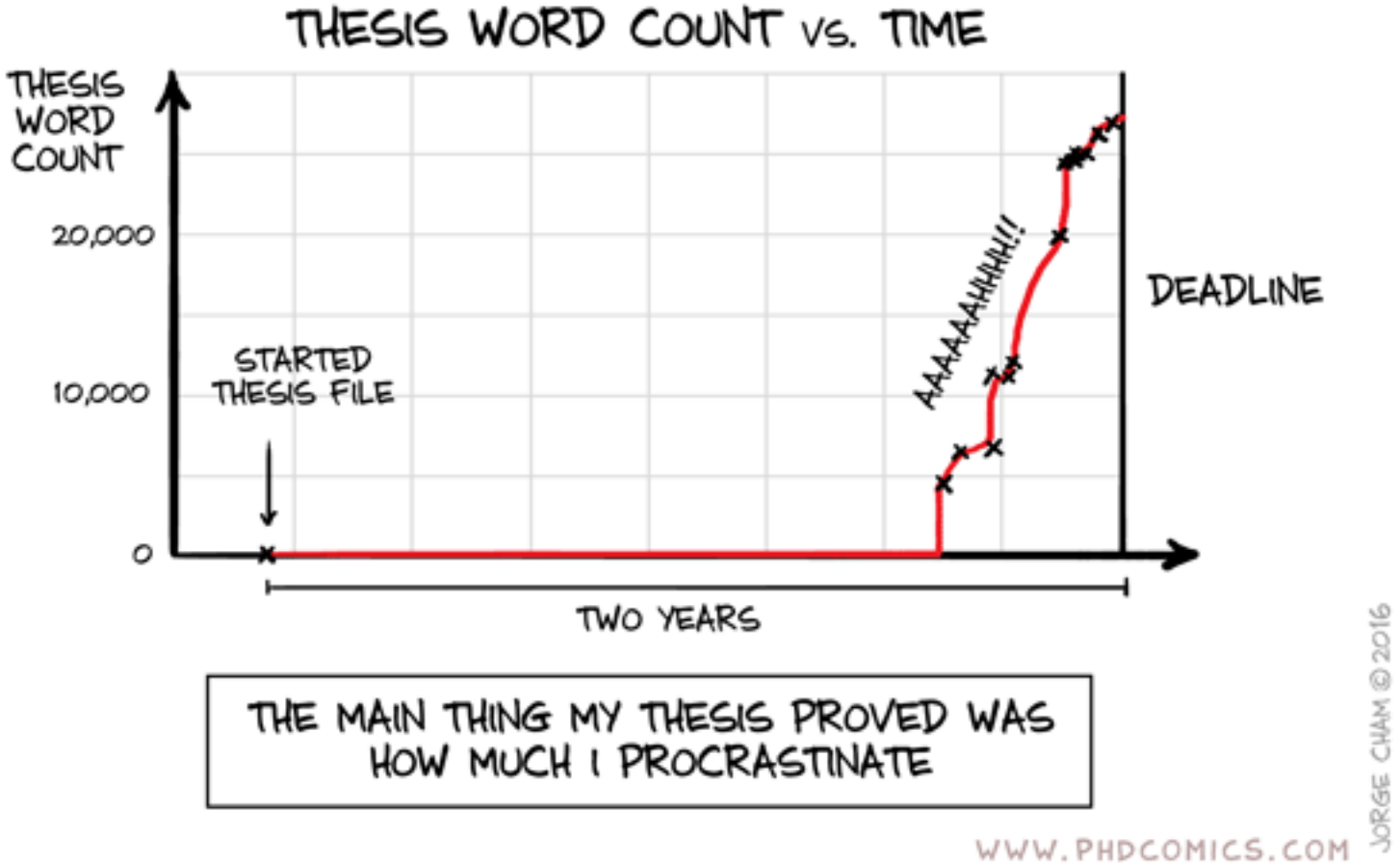
# Pitfalls

- Start to broad: “In 16xx Newton changed the world by inventing calculus.”
- Statements that are probably true but without references: “Multilevel algorithms are among the most efficient.“
- Assume that the reader knows what you are describing so that you do not need to introduce terms or concepts.
- Do not spend to much time on fancy language – the language should be straightforward and to the point

# Tip

- Search for recent works – they provide recent overviews of the fields (although tailored to their story)
- It is not sufficient to read textbooks – they are structured differently and there is no need for novelty in a textbook
- Avoid adjectives such as better, faster, etc. Quantify instead.
- Try to be precise and complete in your writing – draft early with this in mind to get an overview of what you will need to include

# Ways of structuring the writing



# A good way of structuring the writing: focus on one paragraph at the time