Goals for doctoral degree (Higher Education Ordinance 1993:100)

A. Knowledge and understanding

For a doctorate degree, the student shall:

A1. [HEO learning outcome No. 1]

Show broad knowledge within, and a systematic understanding of, the research area [biotechnology], as well as deep and current specialist knowledge within a defined area of the research field [relating to dissertation work].
[for licentiate degree, the underlined should be excluded]

This goal can be achieved through, for example:

- To conduct own research in the field of research.
- To read scientific articles, take courses and participate actively in conferences, seminars and workshops in the field of research.

NN's individual goals are as follows:
To demonstrate broad knowledge within, and a systematic understanding of biotechnology, as well as deep and current specialist knowledge in [naming the field of dissertation].

NN's planned activities to achieve the objectives are as follows:

- To carry out the planned projects in [name the area of the dissertation work], with particular depth and focus on [specify if possible].
- To participate in the writing of scientific articles based on own research results.
- To actively search for and read articles in the research area.
- Presenting own results at conferences, workshops and seminars in the field and taking both comprehensive and in-depth courses in the field.

Evaluation of goal fulfillment:
The goal can be evaluated by eg:

- Completed courses, published articles based on own research results, presentations at conferences and workshops

Comment on one of two different options:
(A) NN is well on track to achieve this goal by ... (during ongoing studies)
(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- NN has demonstrated both broad and deep knowledge in biotechnology by completing X projects in the field (of which X have so far resulted in published work), which have led to new methodologies with potential for becoming useful to researchers in the field (see bibliography list)
- NN has actively and independently searched for, read and interpreted a large number of articles in the field (see reference lists in articles and the dissertation's "kappa").
- NN has passed X number of courses, and obtained XX hp for the course part (see course list).
- NN has actively participated in the following conferences where own results have been well-reported and explained to other researchers:
- Conference XX (2013): Poster - Conference YY (2015): Oral presentation

A2. [HEO learning outcome No. 2]

Show familiarity with research methodology in general and the methods of the specific field [Biotechnology] of research in particular.

[for licentiate degree, less emphasis on the underlined]

This goal can be achieved through, for example:

- To learn to identify relevant research issues and to conduct own research to answer them.
- To read many scientific articles in the field, partly to acquire knowledge of what has already been done, and to critically discuss the content of these in relation to already existing knowledge in the field, chosen methods of planning experiments, results obtained and drawn conclusions.
- To study courses in science theory and research methodology.

NN's individual goals are as follows:

To demonstrate theoretical and practical familiarity with scientific methodology in general and with methods in biotechnology and [name the field of dissertation work] in particular.

NN's planned activities to achieve the objectives are as follows:

- Identify relevant issues within [naming the field of dissertation] and carry out own research to answer them.
- To read many scientific articles in the field, partly to acquire knowledge of what has already been done and to critically discuss the content of these in relation to already existing knowledge in the field, chosen methods, planning of experiments, results obtained and drawn conclusions.
- To study the course *1N5113 Theory of Science and Research Method, Technological and Natural Sciences 7,5 credits*, to gain familiarity with scientific methodology in general.

Evaluation of goal fulfillment:

The goal can be evaluated by eg:

- Completed courses in the subject of scientific methodology, demonstrated ability to account for how an issue is identified and answered.

Comment on one of two different options:

(A) NN is well on track to achieve this goal by ... (during ongoing studies)

(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- NN has testified to acquire knowledge of what has already been done in the field [name the area concerning the dissertation work] and to critically discuss the content of these in relation to already existing knowledge in the field, chosen methods, planning of experiments, results obtained and drawn conclusions
- With this knowledge, NN has been able to identify relevant issues within [naming the field of dissertation] and carry out own research to answer them.
- Furthermore, NN has studied and passed the course *1N5113 Theory of Science and Research Method, Technological and Natural Sciences 7,5 credits*, which provided familiarity with scientific methodology, generally chosen methods, planning of experiments, results obtained and drawn conclusions.

B. Skills and abilities

For a doctorate degree, the student shall:

B1. [HEO learning outcome No. 3]

Demonstrate the capacity for scholarly analysis and synthesis as well as to review and assess new and complex phenomena, issues and situations autonomously and critically.

[for licentiate degree, overall less emphasis on the level of these abilities]

This goal can be achieved through, for example:

- To practice analyzing / interpreting and compiling different types of information into a relevant context.
- Practice thinking multidisciplinary.
- To practice to autonomously evaluate reasons for why an attempt/experiment did not show the expected result, and to propose own suggestions of how such insights can be used to advance the project/problem formulation, and/or generate ideas for new problem formulations.

NN's individual goals are as follows:

To demonstrate the capacity for scholarly analysis and synthesis as well as to independently review and assess new and complex phenomena, issues and situations autonomously and critically.

NN's planned activities to achieve the objectives are as follows:

- To, during the study period, practice autonomous and critical analysis and evaluation of different types of information, such as own experimental results, literature tasks, presentations at conferences, etc., and on this basis, propose how these insights can be combined to advance the problem formulation (i.e., scientific analysis and synthesis).
- To practice critical analysis and interpretation of complex results from different experiments, including those that are unexpected, and from this, identify opportunities for new knowledge and new issues.

Evaluation of goal fulfillment:

The goal can be evaluated by eg:

- Demonstrated capacity for complex and interdisciplinary thinking, and scientific synthesis.

Comment on one of two different options:

(A) NN is well on track to achieve this goal by ... (during ongoing studies)

(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- NN has on several occasions made proposals for new experiments / projects where results and insights from own experiments have been combined with published findings, even from unrelated areas. Two of the papers in the thesis (XX and YY in the bibliographic list) derive from such project proposals.
- NN has shown a very good ability for so-called "trouble shooting". In one case, NN was able to interpret an unexpected result, and realized that this was due to an unknown activity of one of the proteins studied, which led to a more detailed study of the new activity, which was later used as a separate problem formulation (paper ZZ in the bibliographic list).
- Provide examples and evaluate how NN has taken the opportunity to review results and manage new challenges, including relevant courses.

B2. [HEO learning outcome No. 4]

Demonstrate the ability to critically, independently, creatively and with scientific accuracy identify and formulate issues, as well as to plan and adequately conduct research and other qualified tasks within given time frames and to review and evaluate such work.

[for licentiate degree, "conduct research" should be substituted by "to carry out limited research work", and "review" is excluded]

This goal can be achieved through, for example:

- To practice to autonomously plan and perform studies/experiments in an authoritative manner, including an overview of already existing literature to be able to formulate a relevant scientific problem/hypothesis that requires explanation/testing, plan suitable, relevant experiments, and include relevant control experiments.
- Reading courses in scientific methodology. Courses in the subject are organized by KTH: eg.
  1N5113 Theory of Science and Research Method, Technological and Natural Sciences 7,5 credits
  AK2036 Theory and Methodology of Science with Applications (Natural and Technological Science) 7,5 credits

NN's individual goals are as follows:

To independently plan a new project, including a formulation of the question(s) to be answered and the choice of scientific methodology to do this.

NN's planned activities to achieve the objectives are as follows:

- Being involved in, and gradually becoming increasingly independent for planning of new projects, including the problem formulation(s) and choice of scientific methodology.
- Reading the course *1N5113 Theory of Science and Research Method, Technological and Natural Sciences 7,5 credits*, to gain familiarity with scientific methodology in general.

Evaluation of goal fulfillment:

The goal can be evaluated by eg:

- Proven ability to plan a new project, incl. a formulation of the question(s) to be answered and the choice of scientific methodology.

Comment on one of two different options:

(A) NN is well on track to achieve this goal by ... (during ongoing studies)

(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- NN has demonstrated a gradual development and maturation towards this goal, and is today, after four years of studies, able to identify new scientific issues and to plan appropriate procedures for answering these questions. Paper YY in the bibliography list is an example of such a project.

B3. [HEO learning outcome No. 5]

With a dissertation demonstrate the ability to contribute <u>significantly</u> to knowledge development through own research.

[for licentiate degree, the underlined is excluded]

This goal is achieved by:

The student's doctoral thesis.

NN's individual goals are as follows:

To plan and execute projects (original work) within the [name area of the dissertation] of such quality that the results can be published in peer-reviewed scientific journals.

Evaluation of goal fulfillment:

The objective is fulfilled by the doctoral student's own thesis.

Comment on one of two different options:

(A) NN is well on track to achieve this goal by ... (during ongoing studies)

(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- NN is well on track to achieve this goal as s(he) today, after two years of study, has presented own results during a half-time seminar / written and defended a licentiate thesis.
- NN is progressing well towards fulfillment of this objective in that s(he) at this point, after three years of studies, has completed three papers, of which two have already been published in peer-reviewed scientific journals.
- The work to write an introduction to the research subject and scientific problem for the thesis (kappa) has been initiated.

B4. [HEO learning outcome No. 6]

In national and international context, to show the ability to present and discuss research and research findings authoritatively in speech and writing, and in dialogue with the academic community and society in general.
[for licentiate degree, "authoritatively" is replaced by "clearly"]

This goal can be achieved through, for example:

- To participate in, and gradually become increasingly responsible for the writing of scientific articles.
- Practice to present, discuss and defend own results orally or with a poster.
- Reading courses on the subject, eg:
  DS3102 Writing Scientific Articles 5,0 credits
  LS3105 Presentation Skills for Researchers 2,0 credits
  LS3104 Visualize your science 4,0 credits
  Third-cycle seminar courses at the CBH school, which are specifically adapted to develop presentation skills.

NN's individual goals are as follows:

- To autonomously write scientific articles containing an introduction to the field, a summary of own results, and to discuss these results in relation to other research findings.
- To be able to present and discuss research results.

NN's planned activities to achieve the objectives are as follows:

- Being involved in, and gradually becoming increasingly independent, responsible for the completion of scientific articles based on their own results.
- To study the course *DS3102 Writing Scientific Articles 5,0 credits.*
- Attending seminar courses at CBH School, where presentation techniques and the ability to discuss research results are practiced.
- To participate in scientific conferences, either through oral presentations or posters.

Evaluation of goal fulfillment:
The goal can be evaluated by eg:

- A proven ability to write scientific articles containing an introduction to the field, a summary of own results, and to discuss these results in relation to other research findings.
- Having participated in scientific conferences with oral presentations or poster contribution.
- Completing seminar courses where presentation techniques and the ability to discuss research results are practiced.

Comment on one of two different options:
(A) NN is well on track to achieve this goal by ... (during ongoing studies)
(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- NN has gradually shown an ability to assume greater responsibility for the completion of the articles written based on project results. For the latter articles, NN has been main responsible for completion (the work XX and YY in the bibliography list).
- NN has actively participated in the following conferences where its own results have been well-reported and explained to other researchers: Conference XX (2013): Poster; Conference YY (2015): Oral presentation
- NN has completed two seminar courses at the CBH School, where presentation techniques and the ability to discuss research results are practiced (see course list).
- By reading the course *DS3102 Writing Scientific Articles 5,0 credits*, NN has acquired basic skills in presenting research results by writing scientific articles.
- NN has presented and defended research results at a licentiate seminar [or half-time seminar, quarterly seminar etc]
- NN has studied the course *LS3104 Visualize your science 4,0 credits*, which contributed to the development of NN's visual communication skills.

B5. [HEO learning outcome No. 7]

Show the ability to identify the need for additional knowledge.

[for licentiate degree, this learning outcome should read, "Demonstrate the ability to identify the need for further knowledge and the ability to take responsibility for own knowledge development"]

This goal can be achieved through, for example:

Keeping informed about the research area while thinking critically and creatively.

NN's individual goals are as follows:

To independently identify the need for additional knowledge.

NN's planned activities to achieve the objectives are as follows:

- To keep informed about current research in biotechnology in general, bordering areas, and in particular the own area [name the field of the thesis work]; and to use this information to identify and formulate issues that would be motivated to investigate either from a basic research perspective or in an applied context.
- During the study period, to participate in project planning work, both regarding the continuation of ongoing projects and the planning of new projects, and in this work learn to identify potential need for new knowledge before the project can be planned.

Evaluation of goal fulfillment:

The goal can be evaluated by eg:

- A proven ability to identify the need for additional knowledge in different contexts.

Comment on one of two different options:

(A) NN is well on track to achieve this goal by ... (during ongoing studies)

(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- NN has increasingly been able to suggest and independently search for courses / literature / conferences deemed necessary to progress in the projects.
- In addition, NN has in several cases independently come up with proposals for new issues within the area of potential for moving the project forward. In two cases, this has led to applications to the Swedish Research Council and Formas that NN was involved in designing. In one case (VR), the application was granted and a paper from that project is included as a manuscript in NN's thesis.

B6. [HEO learning outcome No. 8]

Within research and education as well as in other qualified professional contexts, to demonstrate the capacity to contribute to societal development and support the learning of others.

[for licentiate degree, this learning outcome is rephrased as "Demonstrate the skills required to participate independently in research and development work and to independently work in other qualified activities"]

This goal can be achieved through, for example:

- Being able to identify issues that can contribute to a better society
- To develop one's educational skills.
- To actively participate in teaching and supervision, including lectures and supervision of project and graduate students, as well as being an assistant in laboratory courses and exercises.
- Attending the "third task", *i.e.*, to disseminate information about science and own research into society or to participate in entrepreneurial contexts.

NN's individual goals are as follows:

To develop to be able to contribute to community development and to support the learning of others.

NN's planned activities to achieve the objectives are as follows:

- During the study period, to supervise graduate workers, participate as an assistant in laboratory courses for primary education students, and to host visiting high school classes.
- To present own research during at conferences, workshops and more popular science contexts such as "Öppet hus" and in the media.
- To read the course *LH3000 Basic Communication and Teaching 3,0 credits.*
- To read the course *BB3120 Supervision Methodology for Diploma Projects 6,0 credits.*

Evaluation of goal fulfillment:

The goal can be evaluated by eg:

- A demonstrated ability to contribute to community development and to support the learning of others.

Comment on one of two different options:

(A) NN is well on track to achieve this goal by ... (during ongoing studies)

(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- During the course of study time, NN has shown a very good ability to educate undergraduate students in graduation and laboratory courses.
- NN has participated in "Öppet hus" activities at the school on numerous occasions, and presented own projects at a popular science level.
- NN has studied and passed the course *LH3000 Basic Communication and Teaching 3,0 credits.*
- During the study period, NN has written a detailed and educational instruction to a central experimental part that is used in the laboratory.
- NN has studied and passed the course *BB3120 Supervision Methodology for Diploma Projects 6,0 credits*, and as part of fulfilling the course's intended learning outcomes, NN has supervised students during the bachelor thesis project *BB103X Degree Project in Biotechnology, First Cycle 15,0 credits.*
- NN has... (entrepreneurial activities, commissions of trust etc.)
- NN has engaged in dialogs with the surrounding society, such as [popular scientific articles and presentations, science pods, etc.]

C. Judgment and approach

For a doctorate degree, the student shall:

C1. [HEO learning outcome No. 9]

Show intellectual autonomy and disciplinary rectitude as well as the ability to make assessments of research ethics. [for licentiate degree, this learning outcome should read "Demonstrate the ability to make assessments of research ethics in own research"]

This goal can be achieved through, for example:

- To be able to carry out research tasks with scientific discretion.
- To independently formulate and investigate self-formulated questions.
- Being able to make research ethical assessments.

NN's individual goals are as follows:

- To be able to carry out research tasks with scientific discretion.
- Being able to argue and act in order to propel own scientific beliefs.
- When applicable, carry out research ethical assessments and act accordingly.
- Be able to reflect on the possibilities and limitations of science, its role in society and people's responsibility for how it is used.

NN's planned activities to achieve the objectives are as follows:

- To carry out own research projects with scientific discretion, etc., as above.
- Read courses that cover with these issues, such as the KTH courses:
  1N5113 Theory of Science and Research Method, Technological and Natural Sciences 7.5 credits
  1N5115 Introduction to Research Ethics 3,0 credits
  AK2036 Theory and Methodology of Science with Applications (Natural and Technological Science) 7.5 credits
  AK2008 Ethics of Biotechnology 7.5 credits

Evaluation of goal fulfillment:
The goal can be evaluated by eg:

- A demonstrated ability to contribute to community development and support the learning of others.

Comment on one of two different options:
(A) NN is well on track to achieve this goal by ... (during ongoing studies)
(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- During the study period, NN has been involved in four projects, all of which were carried out in accordance with scientific honesty. In discussions, for example, experiments that did not generate the expected results were reported in detail, and own mistakes that were made during certain experiments were reported without the need for me as supervisor to request it.
- In a project that could have involved animal experiments, NN invited the project group to consider that the tests instead were based on cell lines due to ethical concerns, which also became the way in which the experiment was finally conducted (work X in the bibliography list).
- NN has demonstrated great scientific and intellectual integrity, and pushed through a proprietary project, despite a skeptical audience. The project generated very interesting results that surprised colleagues in the department (work Y in the bibliography list).
- NN has studied and passed the course *1N5115 Introduction to Research Ethics 3,0 credits.*
- NN has studied and passed the course *AK2036 Theory and Methodology of Science with Applications (Natural and Technological Science) 7.5 credits*, in which issues regarding general research ethics and biotechnology-related issues have been addressed. These skills have matured during the research studies.
- NN has participated in discussions with supervisors and others regarding project-specific and general ethical issues (data processing, driving forces behind ethical attitude, relation to other, intersocial aspects).

C2. [HEO learning outcome No. 10]

Show <u>in-depth</u> insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used. (fulfillment of sustainability goals can be added here in C2)

[for licentiate degree, the underlined should be excluded]

This goal can be achieved through, for example:

- To carry out relevant research projects in the field of biotechnology with scientific honesty, and to summarize and publish results from these in internationally peer-reviewed international journals.
- Alternatively, a monograph can be presented (see "Study plan for the research education subject biotechnology").
- Being oriented in the field of research, and as part of the dissertation, being able to write a field overview (kappa).

NN's individual goals are as follows:

- To participate in a significant and identifiable way in a number of (typically four) relevant research projects conducted with scientific discretion, and with the potential to result in publications in internationally peer-reviewed journals.
- To keep informed about the research area in order to write a field overview that may constitute a so-called "kappa" in the thesis.

NN's planned activities to achieve the objectives are as follows:

- To conduct own research projects with scientific honesty, creativity, ethical assessments, etc. as described above.
- Being involved in, with gradually increasing responsibility for, summarizing results from projects in scientific manuscripts.
- Keeping informed in the field by searching and reading literature, participating in conferences and courses.
- Practice the ability to write scientific text, including to take the course *DS3102 Writing Scientific Articles 5,0 credits.*

Evaluation of goal fulfillment:

The goal can be evaluated by eg:

A finalized thesis in the field of Biotechnology.

Comment on one of two different options:

(A) NN is well on track to achieve this goal by ... (during ongoing studies)

(B) The goal is considered fulfilled by ... (at the exam, final eISP):

Examples of motivation:

- During the study period, NN has been involved in four projects. The current bibliography includes:
    1) NN et al. Journal of... (published)
    2) Olsson, P., NN et al. Journal of... (published)
    3) NN et al. Journal of... (submitted for peer-review)
    4) NN et al. (manuscript)
- NN is far in the process of completing a historical and current area overview to be included in the dissertation.
- NN has demonstrated an understanding of the importance of approach the environment in a sustainable way (in the lab, in the office, outside the work) by ...
- NN has participated in a workshop for PhD students covering the subject sustainable development.