Biotechnology

Study plan for third-cycle subject

The subject plan was approved by Fakultetsnämnden (Faculty Board) January 25, 2011. Valid from Spring 11.

Subject title

Biotechnology (Bioteknologi)

Subject description and programme outcomes

Scientific field

Biotechnology can be described as the integration of natural sciences and engineering to utilise organisms, cells, parts thereof or their molecular equivalents, as products and in processes. Further, the UN's definition of biotechnology is: "Technological applications that utilise biological systems, living organisms or derivatives thereof to produce or modify products or processes for special uses".

Description of possible specialisation

1. Biochemistry
2. Bioprocess technology
3. Molecular biotechnology
4. Glycoscience
5. Gene technology
6. Bioinformatics and systems biology
7. Nanobiotechnology

Specification of how the programme outcomes are to be achieved

The general aim and the goals for doctoral program in Biotechnology is in agreement with the guidelines for third-cycle courses and study programmes that has been established by KTH's Faculty board:

- The aim of research level (third-cycle) education of KTH is to provide society with qualified researchers that can contribute to a sustainable development of the society.
- The goal of KTH's education for third-cycle studies is that the doctoral students should become independent, excellent researchers. The research level (third-cycle) students should, after completed studies, be able to:
  - describe and explain theories and empirical results in his/her field of research.
  - formulate specific research issues in this field of research.
  - use scientific methods and develop new knowledge through his/her own scientific studies.
  - critically analyse and evaluate methods applied and results from his/her own scientific studies and those of others.
  - present and discuss research results in the scientific community.
  - present research in a pedagogical manner outside the scientific community, and also in an educational context.
  - assess ethical aspects of research within the current field and act from these and
  - identify the need for new knowledge and have knowledge of how to initiate and lead research
Biochemistry

Description of the specialisation

Research and third-cycle courses and study programmes in Biochemistry include general biochemistry, but with an emphasis on its use in technical processes and systems. This involves an ambition toward an increased understanding of the function and the regulation of cellular components and the molecular processes and structures that constitute the basis for different forms of life.

Current research

Current research domains include e.g. different aspects of basic and applied enzymology, including studies of the molecular characteristics that lead to observed properties, as well as theoretical modelling and execution of changes to enzymes and substrates at the molecular level, to achieve desired properties and activities in different environments and biotechnical applications. The research also includes ecological biotechnology for development of environmentally friendly methods as alternatives to toxic biocides in forest and agriculture.

Programme structure

The education for third-cycle studies in Biochemistry contains both a course module and a dissertation portion.

Courses are classified as advanced courses, skills courses, broadening courses or other courses. Certain courses are compulsory for students in a certain specialisation within Biochemistry.

Courses can be arranged by the home university (KTH), some other national or international university, institutes or companies (see Section 2.4). Observe that the quality and the level of courses that are arranged by other organisations than universities must be reviewed and be accepted by the director of third-cycle education (forskarutbildningsansvarig) before these can constitute a part of the course block in an individual study plan. In those cases where a Degree of Licentiate is not the end goal, it is recommended that a 2-year seminar (2-Års-seminarium) be held by the student after approximately 20-26 months of studies, at which so-far achieved results are described, including both the dissertation as well as the course module, as well as that a general plan over the continuation of the studies is presented. Two senior researchers are appointed as reviewers and participate at a follow-up meeting, together with the student the principal supervisor and assistant supervisor, and hold a constructive discussion of the planning of the continued studies toward Degree of Doctor.

Compulsory and recommended courses

A Degree of Licentiate includes a course module of at least 30 credits and a dissertation portion equivalent to 90 credits that together constitute an education of 120 credits (equivalent to two years of full-time studies). At least 50% of the credits (15 credits) should be constituted by courses for third-cycle studies.

A Degree of Doctor includes a course module of at least 60 credits and a dissertation portion equivalent to 180 credits that together constitute an education of 240 credits (equivalent to four years of full-time study). At least 60% of the credits (= 36 credits) should be constituted by courses for third-cycle studies.

A list of compulsory and recommended courses for the specialisation Biochemistry can be seen in appendix 3 (Course description). Compulsory courses in the specialisation:

TBD Biotechnology, reading course,

1N5113 Theory of Science and Research Method

LH200V Basic Communication and Teaching

Inclusion of previously read courses
Under certain conditions, courses that the student has read before admission to third-cycle courses at KTH can be included as part of the course requirements, after approval of the principal supervisor and consulting with KTHs regulatory framework with respect to inclusion of previously read courses. Observe that 60% of the credits that are required for Degree of Doctor must be courses for third-cycle studies. Inclusion can not be invoked for courses taken that are required for admittance to third-cycle courses and study programmes at KTH.

Further, to make use of the education at third-cycle in the specialisation Biochemistry, students need to have acquired an advanced knowledge in the subjects equivalent to the following courses at KTH:

- BB1030 Microbiology
- BB1080 Biochemistry
- BB2020 Molecular Enzymology

These so-called “specific entry requirements,” concerning courses or other requirements of prior knowledge that are considered necessary to make use of the education for third-cycle studies implies that these courses, or the equivalent such, cannot be counted as part of the individual course block of 60 credits.

**Thesis**

A thesis is a compulsory part of the education for third-cycle studies. As supplements to the general evaluation process at KTH concerning the quality of theses (see: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policy-forforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for the extent and quality of doctor and licentiate theses: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policy-forforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), should the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for extent and quality for doctor- and licentiate dissertations.

Circumstances that cause these criteria to be considered not applicable or relevant should be discussed with the director of graduate studies and the dean at the School of Biotechnology, KTH.

**Doctoral thesis**

**Compilation thesis**

- The thesis should normally be based on four articles.
- Normally two of the included articles should be either already published or formally accepted for publication ("in press") in international, refereed ("peer reviewed") scientific magazines. Other articles may be included as manuscripts sent in for publication ("submitted") in international refereed ("peer reviewed") scientific magazines.
- The doctoral student should be first-author on at least two of the included articles, including on one of the articles that belong the category "already have published or accepted for publication".
- For all of the included articles should the doctoral student's own contribution be significant and clearly indentifiable.
- The thesis should previewed before printing by at least one senior researcher as well as the principal supervisor.
- In those cases where a thesis is only based on manuscripts that have not yet been published or accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines, the thesis and the included manuscripts should be previewed before printing by at least one senior researcher, the principal supervisor, the opponent, and the examining committee.

**Monograph**

- Monographs should be avoided. KTH has a stated ambition that the contents of theses should be published in international refereed ("peer reviewed") scientific magazines.
- The thesis should be previewed before printing by at least two senior researchers, the principal supervisor, and the director of graduate studies.
Licentiate thesis

Compilation thesis

- The thesis should normally be based on two articles.
- Included articles need not be already published or formally accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines. However, normally at least one of the included articles should be sent in for publication ("submitted") in an international refereed ("peer reviewed") scientific magazine.
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Bioprocess technology

Description of the specialisation

Research and third-cycle courses and study programmes in Bioprocess technology include research in all parts of bioprocesses and the aim is to integrate both biological and engineering aspects of the subject. Process-design refers to the development of safe, efficient and environmentally sustainable processes for production of important commercial products and services.

Current research

Current research domains in Bioprocess technology include design of both eukaryotic and prokaryotic cells in order to create tailored organisms for specific purposes. Examples are cells that can take up carbon-rich waste material, organisms that produce large amounts of high-quality products, organisms that can carry out new and specific biocatalytic processes, and organisms that can eliminate toxic substances from contaminated water. These organisms are integrated with an optimisation of cultivation conditions and media, and design and control of the bioreactor, as well as following enrichment and purification steps.

Programme structure

The education for third-cycle studies in Bioprocess technology contains both a course module and a dissertation portion. Courses are classified as advanced courses, skills courses, broadening courses or other courses. Certain courses are compulsory for students in a certain specialisation in Bioprocess technology. Courses can be arranged of home university (KTH) some other national or international university, institutes or companies (see Section 3.4). Observe that the quality and the level on courses that are arranged other organisations than universities must be reviewed and accepted by the director of third-cycle studies (forskarutbildningsansvarig) before these can constitute a part of the course block in an individual study plan. In those cases where a Degree of Licentiate is not the end goal, it is recommended that a 2-year seminar (2-ÅYrs-seminarium) be held by the student after approximately 20-26 months of studies, at which so-far achieved results are described, including both the dissertation as well as the course module, as well as that a general plan over the continuation of the studies is presented. Two senior researchers are appointed as reviewers and participate at a follow-up meeting, together with the student the principal supervisor and assistant supervisor, to have a constructive discussion of the planning of the continued studies toward Degree of Doctor.
The dissertation portion of the education is based on an accumulation of own theoretical and/or experimental data in the research field that leads to the completion of a written thesis that can be defended at a public defence of doctoral thesis at the end of the third-cycle courses and study programmes (see section 3.5). The education takes place under supervision by a principal supervisor together with one or or several assistant supervisor in agreement with a so-called Individual Study plan (ISP) which be updated at least once a year (or more often when necessary) and that should be accepted by the director of third-cycle studies (forskarutbildningsansvarig).

Compulsory and recommended courses

A Degree of Licentiate includes a course module of at least 30 credits and an dissertation portion equivalent to 90 credits that together constitute an education of 120 credits (equivalent to two years of full-time studies). At least 50 the % of the credits (15 credits) should be constituted by courses for third-cycle studies.

A Degree of Doctor includes a course module of at least 60 credits and a dissertation portion equivalent to 180 credits that together constitute an education of 240 credits (equivalent to four years of full-time studies). At least 60 the % of the credits (= 36 credits) should be constituted by courses for third-cycle studies.

A list of compulsory and recommended courses for the specialisation Bioprocess technology can be seen in appendix 3 (Course description). Compulsory courses in the specialisation:

- 3A5202 Mammalian Cell Technology
- 3A5315 Biochemical Analysis and Separation Techniques
- 3A5209 Literature Course in Bioprocess Technology
- 1N5113 Theory, Research and Development, technology and scientific specialisation
- TBD Current Topics in Molecular Biotechnology 1
- LH200V Basic communication and teaching

Inclusion of previously read courses

Under certain conditions, courses that the student has read before admission to third-cycle courses and study programmes at KTH can be included as part of the course requirements, after approval of the principal supervisor and consulting of KTH's regulatory framework with respect to inclusion of previously read courses. Observe that 60% of the credits that are required for Degree of Doctor must be courses for third-cycle studies. Inclusion can not be invoked for courses taken in education programs that are required for admittance to third-cycle courses and study programmes at KTH.

Further, to make use of the education at third-cycle in the specialization Bioprocess technology, students need to have acquired an advanced knowledge in the subjects equivalent to the following courses at KTH:

- BB2480 Energy and Environment
- BB2450 The Cell Factory
- BB2XXX Bioprocess Design

These so-called "specific entry requirements," concerning courses or other requirements of prior knowledge that are considered necessary to make use of the education at third-cycle implies that these courses, or the equivalent such, cannot be counted in as part of the individual course block of 60 credits.

Thesis

A thesis is a compulsory part of the education for third-cycle studies. As supplements to the general evaluation process at KTH concerning the quality of theses (see: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policy-forforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), the following criteria,
representing an intradisciplinary practice and norm, apply as guidelines for the extent and quality of doctor and licentiate theses: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policyforforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), should the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for extent and quality for doctors- and licentiate theses.

Circumstances that cause these criteria to be considered not applicable or relevant should be discussed with the director of graduate studies and the dean at the School of Biotechnology, KTH.

Doctoral thesis

Compilation thesis

- The thesis should normally be based on four articles.
- Normally two of the included articles should be either already published or formally accepted for publication ("in press") in international, refereed ("peer reviewed") scientific magazines. Other articles may be included as manuscripts sent in for publication ("submitted") in international refereed ("peer reviewed") scientific magazines.
- The doctoral student should be first-author on at least two of the included articles, including on one of the articles that belong the category 'already have published or accepted for publication'.
- For all of the included articles should the doctoral student's own contribution be significant and clearly indentifiable.
- The thesis should previewed before printing by at least one senior researcher as well as the principal supervisor.
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- Monographs should be avoided. KTH has a stated ambition that the contents of theses should be published in international refereed ("peer reviewed") scientific magazines.
- The thesis should be previewed before printing by at least two senior researchers, the principal supervisor, and the director of graduate studies.

Licentiate thesis

Compilation thesis

- The thesis should normally be based on two articles.
- Included articles need not be already published or formally accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines. However, normally at least one of the included articles should be sent in for publication ("submitted") in an international refereed ("peer reviewed") scientific magazine.
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Molecular biotechnology

Description of the specialisation

Research and education at the third-cycle level in Molecular biotechnology include design and production of modified microorganisms and their biomolecular components for biotechnological applications. The field includes an engineering view on the creation of both proteins and nucleic acids via both rational and combinatorial procedures for applications in diagnostics, bioseparation, and treatment and involves both biological and synthetic production methods of such biomolecules.

Current research

Current research areas in Molecular biotechnology include development and use of different platform technologies for analysis of biomolecule libraries, including several so-called "display-techniques". A special focus is applied to the field of biomolecular recognition, involving, amongst others, studies and development of proteins/enzymes with desired binding properties, and new measurement principles for biosensors. The application area for developed reagents is broad and includes e.g. bioseparation, cell biology, in vitro diagnostics, in vivo diagnostics (so-called "in vivo imaging") and treatment.

Programme structure

The education for third-cycle studies in Molecular biotechnology contains both a course module and a dissertation portion. Courses are classified as advanced courses, skills courses, broadening courses or other courses. Certain courses are compulsory for students in a certain specialisation in Molecular biotechnology. Courses can be arranged of home university (KTH) some other national or international university, institutes or companies (see Section 4.4).

Observe that the quality and the level on courses that are arranged other organisations than universities must be reviewed and accepted by the director of third-cycle studies (forskarutbildningsansvarig) before these can constitute a part of the course block in an individual study plan. In those cases where a Degree of Licentiate is not the end goal, it is recommended that a 2-year seminar (2-Års-seminarium) be held by the student after approximately 20-26 months of studies, at which so-far achieved results are described, including both the dissertation portion as well as the course module, as well as that a general plan over the continuation of the studies is presented. Two senior researchers are appointed as reviewer and participate at a follow-up meeting, together with the student, the principal supervisor and assistant supervisor, for a constructive discussion of the planning of the continued studies toward Degree of Doctor.

The dissertation portion of the education is based on an accumulation of own theoretical and/or experimental data in the research field that leads to the completion of a written thesis that can be defended at a public defence of doctoral thesis at the end of the third-cycle courses and study programmes (see section 4.5). The education takes place under supervision by a principal supervisor together with one or or several assistant supervisor in agreement with a so called Individual Study plan (ISP) which be updated at least once a year (or more often when necessary) and that should be accepted by the director of third-cycle education (forskarutbildningsansvarig).

Compulsory and recommended courses

A Degree of Licentiate includes a course module of at least 30 credits and an dissertation portion equivalent to 90 credits that together constitute an education of 120 credits (equivalent to two years of full-time studies).

At least 50 the % of the credits (15 credits) should be constituted by courses for third-cycle studies.

A Degree of Doctor includes a course module of at least 60 credits and a dissertation portion equivalent to 180 credits that together constitute an education of 240 credits (equivalent to four years of full-time studies). At least 60 % of the credits (= 36 credits) should be constituted by courses for third-cycle studies.

A list of compulsory and recommended courses for the specialisation Molecular biotechnology can be seen in appendix 3 (Course description). Compulsory courses in the specialisation:

TBD Biotechnology, reading course
1N5113 Theory of Science and Research, technology and natural sciences specialisation

3A5320 Current topics in molecular biotechnology

3A5311 Current topics in bioscience

LH200V Basic communication and teaching

Inclusion of previously read courses requires students to have acquired an advanced knowledge in the subject equivalent to (or similar to) the following courses at KTH:

- BB1030 Microbiology
- BB1110 Gene technology and molecular biology
- BB1130 Analysis and purification of biomolecules

These so-called "specific entry requirements" courses or other requirements of prior knowledge that are considered necessary to make use of the education for third-cycle studies implies that such courses, or the equivalent such, cannot be counted in as part of the individual course block about 60 credits.

Thesis

the general review process at KTH concerning the quality of theses (see: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policyfor-forhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), should the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for extent and quality for doctors- and licentiate theses. Circumstances that cause these criteria to be considered not applicable or relevant should be discussed with the director of graduate studies and the dean at the School of Biotechnology, KTH.

Doctoral thesis

Compilation thesis

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Licentiate thesis

Compilation thesis
The subject plan was approved by Fakultetsnämnden (Faculty Board) January 25, 2011. Valid from Spring 11.

- The thesis should normally be based on two articles.
- Included articles need not be already published or formally accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines. However, normally at least one of the included articles should be sent in for publication ("submitted") in an international refereed ("peer reviewed") scientific magazine.
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Glycoscience

Description of the specialisation

The specialisation Glycoscience can be described as the exploitation of fundamental knowledge of the biosynthesis of cell-wall polysaccharides, including their self-assembly and rearrangement, with multi-disciplinary applications for design and production of new high-technological biomaterials with relevance for several industries. The knowledge that is gained from characterization of enzymes involved in cell wall biosynthesis can be utilised for combating diseases that are caused by microbial pathogens and to characterise modes of action of new, environmentally friendly biocidal substances that are directed to cell-wall biosynthesis (such as herbicides and fungicides).

Current research

Research and third-cycle courses and study programmes in Glycoscience include enzymatic or microbial production, degradation or modification of natural fiber material, such as cellulose and different forms of hemicellulose. The research is focused on glycoscience, including basic research about plants and microorganisms, as well as on biotechnological development of carbohydrate-based/related products.

A larger, general aim is to understand how extracellular polysaccharides in microorganisms and plants- especially trees- are shaped, transformed, and hydrolyzed, and to utilise this knowledge in a large range of applications of relevance for several sectors, including (but not limited to) the forest products industry (development of new pulp and paper processes, high-value nanocomposites and biomimetic materials), the biomedicine industry (e.g. development of carbohydrate-based wound dressings), the agriculture industry (development of technology for production of biofuels and protection of plants) and the aquaculture industry (e.g. development of methods for control of microbial diseases to optimise food production in e.g. fish farms).

Programme structure

The education for third-cycle studies in Glycoscience contains both a course module and a dissertation portion. Courses are classified as advanced courses, skills courses, broadening courses or other courses. Certain courses are compulsory for students in a certain specialisation in Glycoscience. Courses can be arranged of home university (KTH) some other national or international university, institutes or companies (see Section 5.4).

Observe that the quality and the level on courses that are arranged by other organisations than universities must be reviewed and be accepted by the director of third-cycle studies (forskarutbildningsansvarig) before these can constitute a part of the course block in an individual study plan. In those cases where a Degree of Licentiate is not the end goal, it is recommended that a 2-year seminar ("2-Års-seminarium") be held by the student after approximately 20-26 months.
of studies, at which so-far achieved results are described, including both the dissertation portion as well as the course module, as well as that a general plan over the continuation of the studies is presented. Two senior researchers are appointed as reviewer and participate at a follow-up meeting, together with the student, the principal supervisor and assistant supervisor, with a constructive discussion of the planning of the continued studies toward Degree of Doctor.

The dissertation portion of the education is based on an accumulation of own theoretical and/or experimental data in the research field that leads to the completion of a written thesis that can be defended at a public defence of doctoral thesis at the end of the third-cycle courses and study programmes (see section 5.5). The education takes place under supervision by a principal supervisor together with one or or several assistant supervisor in agreement with a so called Individual Study plan (ISP), which be updated at least once a year (or more often when necessary) and that should be accepted by the director of third-cycle studies (forskarutbildningsansvarig).

**Compulsory and recommended courses**

A Degree of Licentiate includes a course module of at least 30 credits and an dissertation portion equivalent to 90 credits that together constitute an education of 120 credits (equivalent to two years of full-time studies).

At least 50% of the credits (15 credits) should be constituted by courses for third-cycle studies.

A Degree of Doctor includes a course module of at least 60 credits and a dissertation portion equivalent to 180 credits that together constitute an education of 240 credits (equivalent to four years of full-time studies). At least 60% of the credits (= 36 credits) should be constituted by courses for third-cycle studies.

A list of compulsory and recommended courses for the specialisation Glycoscience can be seen in appendix 3 (Course description). Compulsory courses in the specialisation:

- **3A5108 Enzyme catalysis**
- **BB3020 Biomimetic fiber technology**
- **TBD Biotechnology, reading course**
- **1N5113 Theory, Research and Development, technology and scientific specialisation**
- **TBD Current topics in glycoscience 1**
- **TBD Current topics in protein and enzyme technology 1**
- **LH200V Basic communication and teaching**

Inclusion of earlier read courses

Under certain conditions, courses that the student has read before admission to third-cycle courses and study programmes at KTH can be included as part of the course requirements, after approval of the principal supervisor and consulting KTHs regulatory framework with respect to inclusion of previously read courses. Observe that 60% of the credits that are required for Degree of Doctor must intend courses for third-cycle studies. Inclusion can not be invoked for courses taken in education programs that are requirements for admission for third-cycle courses and study programmes at KTH.

Further, to make use of the education at third-cycle in the specialization Glycoscience, students need to have acquired an advanced knowledge in subjects equivalent to the following courses at KTH:

- **BB1080 Biochemistry**
- **BB2420 Glycobiology and carbohydrate technology**
- **BB2450 the Cell Factory**
These so-called "specific entry requirements" concerning courses or other requirements of prior knowledge that is considered necessary to make use of third-cycle education implies that these courses, or the equivalent such, cannot be counted in as part of the individual course block of 60 credits.

**Thesis**

A thesis is a compulsory part of the education for third-cycle studies. As supplements to the general evaluation process at KTH concerning the quality of theses (see: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policy-forforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for the extent and quality of doctor and licentiate theses: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policy-forforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), should the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for extent and quality for doctor- and licentiate theses.

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**Doctoral thesis**

**Compilation thesis**

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- For all of the included articles should the doctoral student's own contribution be significant and clearly indentifiable.
- If the thesis contains one or more articles that have been published already or been accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines, the thesis should be previewed before printing by at least one senior researchers as well as the principal supervisor.
- If the thesis does not contain an article that has been published already or been accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines, the thesis should be previewed before printing by at least two senior researchers as well as the principal supervisor.

**Monograph**

- Monographs should be avoided. KTH has a stated ambition that the contents of theses should be published in international refereed ("peer reviewed") scientific magazines.
- The thesis should previewed before printing by at least two senior researchers, the principal supervisor as well as the director of third-cycle studies (forskarutbildningsansvarig).

**Gene technology**

**Description of the specialisation**

Research and education at third-cycle in Gene technology include both methodological and biological aspects of focused- or whole-genome studies of transcriptomes, genomes and epigenomes, including both quantitative and qualitative issues.

**Current research**

Current research domains in Gene technology include method development of large-scale parallelised nucleic-acid sequencing and analysis, related to biological issues of different types, including e.g. the origin and development of cancer, RNA-based gene silencing, stem-cell differentiation, genetic variation and alternative transcript-processing ("splicing"), tree genetics and domestication of animals.

**Programme structure**

The education for third-cycle studies in Gene technology contains both a course module and a dissertation portion. Courses are classified as advanced courses, skills courses, broadening courses or other courses. Certain courses are compulsory for students in a certain specialisation in Gene technology.

Courses can be arranged of home university (KTH) some other national or international university, institutes or companies (see Section 6.4). Observe that the quality and the level on courses that are arranged by other organisations than universities must be reviewed and be accepted by the director of third-cycle studies (forskarutbildningsansvarig) before these can constitute a part of the course block in an individual study plan. In those cases where a Degree of Licentiate is not the end goal, it is recommended that a 2-year seminar ("2-Års-seminarium") be held by the student after approximately 20-26 months of studies, at which so-far achieved results are described, including both the dissertation portion as well as the course module, as well as that a general plan over the continuation of the studies is presented. Two senior researchers are appointed as reviewer and participate at a follow-up meeting, together with the student, the principal supervisor and assistant supervisor, with a constructive discussion of the planning of the continued studies toward Degree of Doctor.

The dissertation portion of the education is based on an accumulation of own theoretical and/or experimental data in the research field that leads to the completion of a written thesis that can be defended at a public defence of doctoral thesis at the end of the third-cycle courses and study programmes (see section 6.5). The education takes place under supervision by a principal supervisor together with one or or several assistant supervisor in agreement with a so called Individual Study plan (ISP) which be updated at least once a year (or more often when necessary) and that should be accepted by the director of third-cycle studies (forskarutbildningsansvarig).

**Compulsory and recommended courses**

A Degree of Licentiate includes a course module of at least 30 credits and an avhandlingsdel equivalent to 90 credits that together constitute an education of 120 credits (equivalent to two years of full-time studies).

At least 50% of the credits (15 credits) should be constituted by courses for third-cycle studies.
A Degree of Doctor includes a course module of at least 60 credits and an dissertation portion equivalent to 180 credits that together constitute an education of 240 credits (equivalent to four years of full-time studies). At least 60% of the credits (= 36 credits) should be constituted by courses for third-cycle studies.

A list of compulsory and recommended courses for the specialisation Gene technology can be seen in appendix 3 (Course description). Compulsory courses in the specialisation:

- TBD Biotechnology, reading course
- 1N5113 Theory, Research and Development, technology and scientific specialisation
- Current trends in high throughput biology 1
- 3A5316 Current trends in DNA/RNA science
- LH200V Basic communication and teaching

Inclusion of previously read courses

Under certain conditions, courses that the student has read before admission to third-cycle courses and study programmes at KTH can be included as part of the course requirements, after approval of the principal supervisor and consulting KTH's regulatory framework with respect to inclusion of previously read courses. Observe that 60% of the credits that are required for Degree of Doctor must intend courses for third-cycle studies. Inclusion can not be invoked for courses taken that are required for admittance to third-cycle courses and study programmes at KTH.

Further, to make use of the education at third-cycle in the specialization Gene Technology, students need to have acquired an advanced knowledge in subjects equivalent to the following courses at KTH:

- BB1030 Microbiology
- BB1110 Gene technology and molecular biology
- BB1130 Analysis and purification of biomolecules

These so-called "specific entry requirements" concerning courses or other requirements of prior knowledge that is considered necessary to make us of third-cycle education implies that these courses, or the equivalent such, cannot be counted as part of the individual course block of 60 credits.

Thesis

A thesis is a compulsory part of the education for third-cycle studies. As supplements to the general evaluation process at KTH concerning the quality of theses (see: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policy-forforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for the extent and quality of doctor and licentiate theses: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policyforforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), should the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for extent and quality for doctor- and licentiate theses.

Circumstances that cause these criteria to be considered not applicable or relevant should be discussed with the director of graduate studies and the dean at the School of Biotechnology, KTH.

Doctoral thesis

Compilation thesis

- The thesis should normally be based on four articles.
- Normally two of the included articles should be either already published or formally accepted for publication (“in press”) in international, refereed (“peer reviewed”) scientific magazines. Other articles may be included as
manuscripts sent in for publication ("submitted") in international refereed ("peer reviewed") scientific magazines.

- The doctoral student should be first-author on at least two of the included articles, including on one of the articles that belong the category "already have published or accepted for publication".
- For all of the included articles should the doctoral student's own contribution be significant and clearly indentifiable.
- The thesis should previewed before printing by at least one senior researcher as well as the principal supervisor.
- In those cases where a thesis is only based on manuscripts that have not yet been published or accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines, the thesis and the included manuscripts should be previewed before printing by at least one senior researcher, the principal supervisor, the opponent, and the examining committee.

### Monograph

- Monographs should be avoided. KTH has a stated ambition that the contents of theses should be published in international refereed ("peer reviewed") scientific magazines.
- The thesis should be previewed before printing by at least two senior researchers, the principal supervisor, and the director of graduate studies.

### Licentiate thesis

### Compilation thesis

- The thesis should normally be based on two articles.
- Included articles need not be already published or formally accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines. However, normally at least one of the included articles should be sent in for publication ("submitted") in an international refereed ("peer reviewed") scientific magazine.
- The doctoral student should emerge as first-author on at least one of the included articles.
- For all of the included articles should the doctoral student's own contribution be significant and clearly indentifiable.
- If the thesis contains one or more articles that have been published already or been accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines, the thesis should be previewed before printing by at least one senior researchers as well as the principal supervisor.
- If the thesis does not contain an article that has been published already or been accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines, the thesis should be previewed before printing by at least two senior researchers as well as the principal supervisor.

### Monograph

- Monographs should be avoided. KTH has a stated ambition that the contents of theses should be published in international refereed ("peer reviewed") scientific magazines.
- The thesis should be previewed before printing by at least two senior researchers, the principal supervisor, and the director of graduate studies.

### Bioinformatics and systems biology

#### Description of the specialisation

Research and education at the third-cycle in Bioinformatics and Systems Biology includes applications of statistics and computer science in the field biological science. Bioinformatics includes creation and development of databases, algorithms, computer science and statistical technologies and theories to solve general and practical problems that arise from handling and analysis of biological data. System biology is an interdisciplinary research field that focuses on complex interactions in biological systems using a holistic rather than a reductionist approach.
Current research

Current research areas in Bioinformatics and Systems Biology include an extensive effort to use experimental data and bioinformatics platforms to be able to survey all individual proteins in the human proteome with regards to their localisation inside cells, bodily fluids, tissues and organs. Special attention is devoted to the differences in abundance and localization that can serve as markers for disease therefore be of diagnostic and therapeutic relevance.

Programme structure

The education for third-cycle studies in Bioinformatics and Systems Biology contains both a course module and a dissertation portion. Courses are classified as advanced courses, skills courses, broadening courses or other courses. Certain courses are compulsory for students in a certain specialisation in Bioinformatics and systems biology. Courses can be arranged of home university (KTH) some other national or international university, institutes or companies (see Section 7.4).

Observe that the quality and the level on courses that are arranged by organisations other than universities must be reviewed and be accepted by the director of third-cycle studies (forskarutbildningsansvarig) before these can constitute a part of the course block in an individual study plan. In those cases where a Degree of Licentiate is not the end goal, it is recommended that a 2-year seminar ("2-Års-seminarium") be held by the student after approximately 20-26 months of studies, at which so-far achieved results are described, including both the dissertation portion and course module, as well as that a general plan over the continuation of the studies is presented. Two senior researchers are appointed as reviewers and participate at a follow-up meeting, together with the student, the principal supervisor and assistant supervisor for a constructive discussion of the planning of the continued studies toward Degree of Doctor.

The dissertation portion of the education is based on an accumulation of own theoretical and/or experimental data in the research field that leads to the completion of a written thesis that can be defended at a public defence of doctoral thesis at the end of the third-cycle courses and study programmes (see section 7.5). The education takes place under supervision by a principal supervisor together with one or several assistant supervisor in agreement with a so-called Individual Study plan (ISP) that is updated at least once a year (or more often when necessary) and that should be accepted by the director of third-cycle studies (forskarutbildningsansvarig).

Compulsory and recommended courses

A Degree of Licentiate includes a course module of at least 30 credits and a dissertation portion equivalent to 90 credits that together constitute an education of 120 credits (equivalent to two years of full-time studies).

At least 50 % of the credits (15 credits) should be constituted by courses for third-cycle studies.

A Degree of Doctor includes a course module of at least 60 credits and a dissertation portion equivalent to 180 credits that together constitute an education of 240 credits (equivalent of four years of full-time studies). At least 60 % of the credits (= 36 credits) should be constituted by courses for third-cycle studies.

A list of compulsory and recommended courses for the specialisation Bioinformatics and systems biology can be seen in appendix 3 (Course description). Compulsory courses in the specialisation:

- TBD Biotechnology, reading course
- 1N5113 Theory, Research and Development, technology and scientific specialisation
- 3A5320 Current issues in molecular biotechnology
- TBD Current topics in bioinformatics and systems biology 1
- LH200V Basic communication and teaching

Inclusion of previously read courses
Under certain conditions, courses that the student has read before admission to third-cycle courses and study programmes at KTH can be included as part of the course requirements, after approval of the principal supervisor and consulting KTHs regulatory framework with respect to inclusion of previously read courses. Observe that 60 % of the credits that are required for Degree of Doctor must intend courses for third-cycle studies. Inclusion can not be invoked for courses taken that are required for admittance to third-cycle courses and study programmes at KTH.

Further, to make use of from third-cycle education in the specialization Bioinformatics and Systems Biology, students need to have acquired an advanced knowledge in subjects equivalent to the following courses at KTH:

- DD2397 Applied Bioinformatics
- B2XXX Proteomics
- BB2440 Bioinformatics and biostatistics

These so-called "specific entry requirements," concerning courses or other requirements of prior knowledge that is considered necessary to make use of third-cycle education implies that these courses, or the equivalent such, cannot be counted as part of the individual course block of 60 credits.

**Thesis**

A thesis is a compulsory part of the education for third-cycle studies. As supplements to the general evaluation process at KTH concerning the quality of theses (see: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning /disputation/policy-forforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for the extent and quality of doctor and licentiate theses: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policyfor- forhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), should the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for extent and quality for doctor- and licentiate theses.

Circumstances that cause these criteria to be considered not applicable or relevant should be discussed with the director of graduate studies and the dean at the School of Biotechnology, KTH.

**Doctoral thesis**

Compilation thesis

- The thesis should normally be based on four articles.
- Normally two of the included articles should be either already published or formally accepted for publication ("in press") in international, refereed ("peer reviewed") scientific magazines. Other articles may be included as manuscripts sent in for publication ("submitted") in international refereed ("peer reviewed") scientific magazines.
- The doctoral student should be first-author on at least two of the included articles, including on one of the articles that belong the category "already have published or accepted for publication".
- For all of the included articles should the doctoral student's own contribution be significant and clearly indentifiable.
- The thesis should previewed before printing by at least one senior researcher as well as the principal supervisor.
- In those cases where a thesis is only based on manuscripts that have not yet been published or accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines, the thesis and the included manuscripts should be previewed before printing by at least one senior researcher, the principal supervisor, the opponent, and the examining committee.

Monograph

- Monographs should be avoided. KTH has a stated ambition that the contents of theses should be published in international refereed ("peer reviewed") scientific magazines.
- The thesis should be previewed before printing by at least two senior researchers, the principal supervisor, and the director of graduate studies.
Nanobiotechnology

Description of the specialisation
Research and education at third cycle within Nanobiotechnology includes development and studies of miniaturized systems for carrying out cellular and biomolecular analyses and manipulations.

Current research
Current research domains in Nanobiotechnology include e.g. development of platforms for fast on-site analysis of biomolecular contents of complex samples, micromatrix formats for parallel and simultaneous analyses of several analytes (“multiplexing”) that are involved in regulation of cell growth. Special attention is given to development of so-called microdoplet systems for transport, encapsulation, analysis and sorting of cells and particles.

Programme structure
The education for third-cycle studies in Nanobiotechnology contains both a course module and an avhandlingsdel.

Courses are classified as advanced courses, skills courses, broadening courses or other courses. Certain courses are compulsory for students in a certain specialisation in Nanobiotechnology. Courses can be arranged of home university (KTH) some other national or international university, institutes or companies (see Section 8.4). Observe that the quality and the level of courses that are arranged by organisations other than universities must be reviewed and be accepted by the director of third-cycle studies (forskarutbildningsansvarig) before these can constitute a part of the course block in an individual study plan. In those cases where a Degree of Licentiate is not the end goal, it is recommended that a 2-year seminar (“2-Års-seminarium”) be held by the student after approximately 20-26 months of studies, at which so-far achieved results are described, including both the dissertation portion as well as the course module, as well as that a general plan over the continuation of the studies is presented. Two senior researchers are appointed as reviewers and participate at a follow-up meeting, together with the student, the principal supervisor and assistant supervisor, for a constructive discussion of the planning of the continued studies toward Degree of Doctor.

The dissertation portion of the education is based on an accumulation of own theoretical and/or experimental data in the research field that leads to the completion of a written thesis that can be defended at a public defence of doctoral thesis at the end of the third-cycle courses and study programmes (see section 8.5). The education takes place under supervision by a principal supervisor together with one or or several assistant supervisor in agreement with a so-called Individual Study plan (ISP) which is to be updated at least once a year (or more often when necessary) and that should be accepted by the director of third-cycle studies (forskarutbildningsansvarig).

Compulsory and recommended courses
A Degree of Licentiate includes a course module of at least 30 credits and an dissertation portion equivalent to 90 credits that together constitute an education of 120 credits (equivalent to two years of full-time studies).

At least 50% of the credits (15 credits) should be constituted by courses for third-cycle studies.

A Degree of Doctor includes a course module of at least 60 credits and an dissertation portion equivalent to 180 credits that together constitute an education of 240 credits (equivalent of four years of full-time study). At least 60% of the credits (= 36 credits) should be constituted by courses for third-cycle studies.

A list of compulsory and recommended courses for the specialisation Nanobiotechnology can be seen in appendix 3 (Course description). Compulsory courses in the specialisation:

TBD Biotechnology, reading course (specialization area specific topic)
1N5113Vetenskapsteori, research methodology and technology and scientific specialisation
3A5320 Current topics in molecular biotechnology
LH200V Basic communication and teaching

3A5801 Current topics in nanobiotechnology

Inclusion of previously read courses

Under certain conditions, courses that the student has read before admission to third-cycle courses and study programmes at KTH can be included as part of the course requirements, after approval of the principal supervisor and consulting of KTH's regulatory framework with respect to inclusion of previously read courses. Observe that 60% of the credits that are required for Degree of Doctor must intend courses for third-cycle studies. Inclusion cannot be invoked for courses taken that are required for admittance to third-cycle courses and study programmes at KTH.

Further, to make use of the education at third-cycle in the specialization Nanobiotechnology, students need to have acquired an advanced knowledge in subjects equivalent to the following courses at KTH:

- BB1110 Gene Technology and Molecular Biology
- BB1130 Analysis and purifying of biomolecules
- BB2XXX Nanobiotechnology

These so-called "specific entry requirements" concerning courses or other requirements of prior knowledge that is considered necessary to make use of third-cycle education implies that these courses, or the equivalent such, cannot be counted as part of the individual course block of 60 credits.

Thesis

A thesis is a compulsory part of the education for third-cycle studies. As supplements to the general evaluation process at KTH concerning the quality of these (see: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policy-forhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for the extent and quality of doctor and licentiate theses: http://intra.kth.se/regelverk/utbildning-forskning/forskarutbildning/disputation/policyforhandsgranskning-av-doktorsavhandling-licentiatuppsats-1.27246), should the following criteria, representing an intradisciplinary practice and norm, apply as guidelines for extent and quality for doctor and licentiate theses. Circumstances that cause these criteria to be considered not applicable or relevant should be discussed with the director of graduate studies and the dean at the School of Biotechnology, KTH.

Doctoral thesis

Compilation thesis

- The thesis should normally be based on four articles.
- Normally two of the included articles should be either already published or formally accepted for publication ("in press") in international, refereed ("peer reviewed") scientific magazines. Other articles may be included as manuscripts sent in for publication ("submitted") in international refereed ("peer reviewed") scientific magazines.
- The doctoral student should be first-author on at least two of the included articles, including on one of the articles that belong the category "already have published or accepted for publication".
- For all of the included articles should the doctoral student's own contribution be significant and clearly indentifiable.
- The thesis should previewed before printing by at least one senior researcher as well as the principal supervisor.
- In those cases where a thesis is only based on manuscripts that have not yet been published or accepted for publication ("in press") in international refereed ("peer reviewed") scientific magazines, the thesis and the included manuscripts should be previewed before printing by at least one senior researcher, the principal supervisor, the opponent, and the examining committee.

Monograph
Monographs should be avoided. KTH has a stated ambition that the contents of theses should be published in international refereed (“peer reviewed”) scientific magazines.

The thesis should be previewed before printing by at least two senior researchers, the principal supervisor, and the director of graduate studies.

Licentiate thesis

Compilation thesis

- The thesis should normally be based on two articles.
- Included articles need not be already published or formally accepted for publication (“in press”) in international refereed (“peer reviewed”) scientific magazines. However, normally at least one of the included articles should be sent in for publication (“submitted”) in an international refereed (“peer reviewed”) scientific magazine.
- The doctoral student should emerge as first-author on at least one of the included articles.
- For all of the included articles should the doctoral student's own contribution be significant and clearly indentifiable.
- If the thesis contains one or more articles that have been published already or been accepted for publication (“in press”) in international refereed (“peer reviewed”) scientific magazines, the thesis should be previewed before printing by at least one senior researchers as well as the principal supervisor.
- If the thesis does not contain an article that has been published already or been accepted for publication (“in press”) in international refereed (“peer reviewed”) scientific magazines, the thesis should be previewed before printing by at least two senior researchers as well as the principal supervisor.

Monograph

- Monographs should be avoided. KTH has a stated ambition that the contents of theses should be published in international refereed (“peer reviewed”) scientific magazines.
- The thesis should be previewed before printing by at least two senior researchers, the principal supervisor, and the director of graduate studies.

Entry requirements and selection

General and special admission requirements and prior knowledge

Entry requirements to Doctoral program in Biotechnology includes part of the general entry requirements for postgraduate studies described in The Higher Education Ordinance, chapter 7, section 39:

Basic entry requirements are, according to Higher Education Ordinance 7 chapters section 39, one that has:

1. been awarded a second-cycle degree,
2. satisfied the requirements for courses comprising at least 240 credits of which at least 60 credits were awarded in the second-cycle, or
3. in some other way, within or outside the country, acquired equivalent knowledge.

The faculty board may allow exceptions from the general entry requirements for an individual applicant if special circumstances apply.

For entry requirements to Doctoral program in Biotechnology, the above described second-cycle qualification or the advanced courses should be in one of the fields, biological life science or biotechnology.

As supplements to these requirements, so-called specific entry requirements can also be made for special focuses. These special requirements include skills necessary to make use of the education and can for example involve knowledge/skills from special fields of importance to the subject area, or linguistic knowledge. The same specific entry requirements apply to students with aims of Degree of Doctor or Degree of Licentiate.
Selection rules and procedures

Selection of students to third-cycle courses and study programmes is first based on if they satisfy the formal requirements for admission. During the application procedure, the applicant's potential to make use of the education is assessed, typically through interviews and an overview of earlier activities, degrees and certificate, but also through an assessment of talent and skill, maturity level, independence, ability to express thoughts in writing and verbally, linguistics and ability for critical thinking. Admission to third-cycle courses and study programmes is made by relevant dean, after assessment from the director of third-cycle studies (forskarutbildningsansvarig) about formal eligibility of the proposed principal advisor and assistant advisor.

The programme’s degrees and examinations

Degree of Licentiate and Degree of Doctor (PhD)

Examination of licentiate and Degree of Doctor are made according to KTHs regulatory framework (see "the KTHhandboken" at http://intra.kth.se). A Degree of Licentiate can constitute a final examination. Even if a Degree of Doctor constitutes final examination, a Degree of Licentiate can first be issued. In short; apart from completing of a full course block of 30 or 60 credits for licentiate respective Degree of Doctor, a defence of the thesis is also required for both types of degrees, written on the basis of results of theoretical and/or practical studies. A licentiate thesis is presented at a public seminar. The licentiate thesis should be reviewed by at least a teacher or senior researchers. The principal supervisor decides if the thesis should be accepted or not. A doctoral thesis is defended at a public seminar, where the thesis is reviewed by a peer reviewer as well as an examining committee consisting of three or five members. The examining committee decides if the thesis should be accepted or not.

The programme’s examinations

Courses in third-cycle courses and study programmes should contain either an oral or written examination. The examiner must in each individual case ensure that the student satisfied the course requirements.