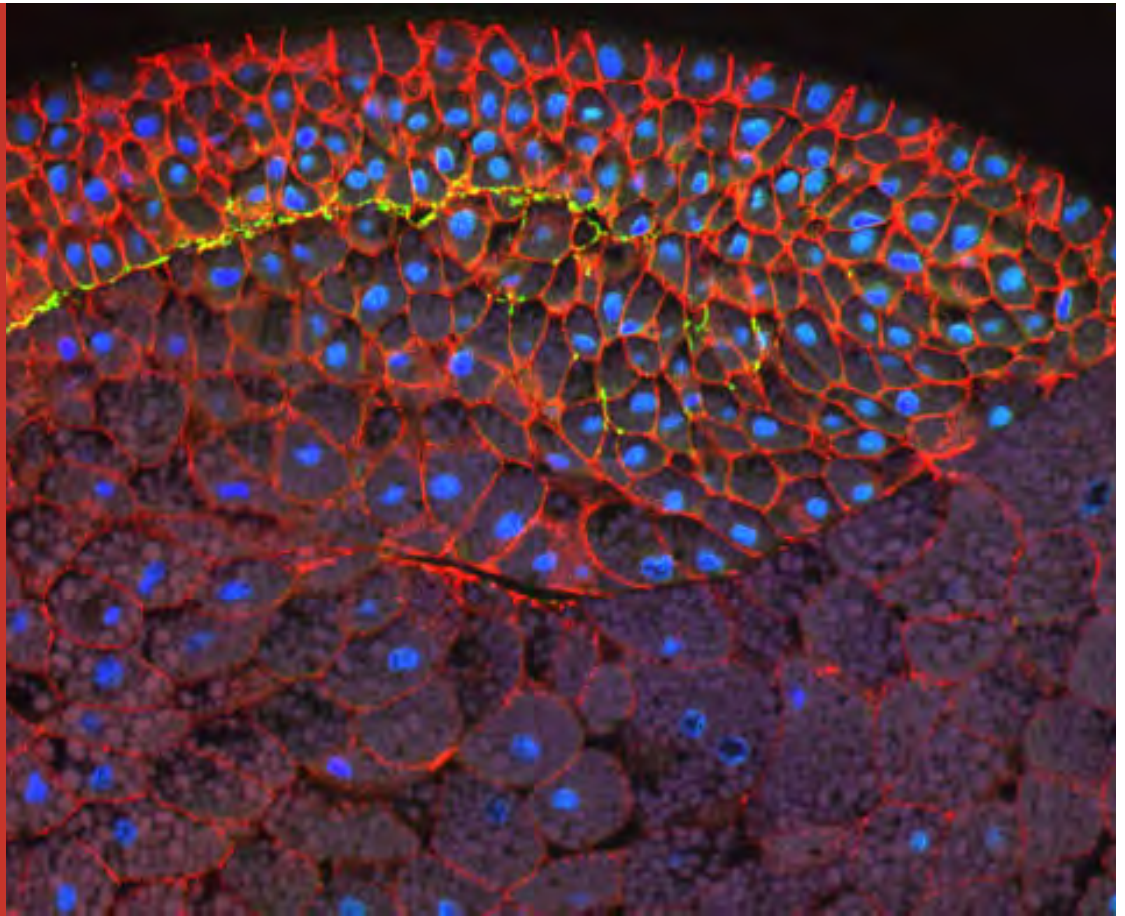


DEVELOPMENTAL BIOLOGY

Developmental Biology is one of the fastest growing biological disciplines in the last years. It is the basic science to understand human development, cancer, and aging and it opens perspective for regenerative medicine.



Research in Developmental Biology

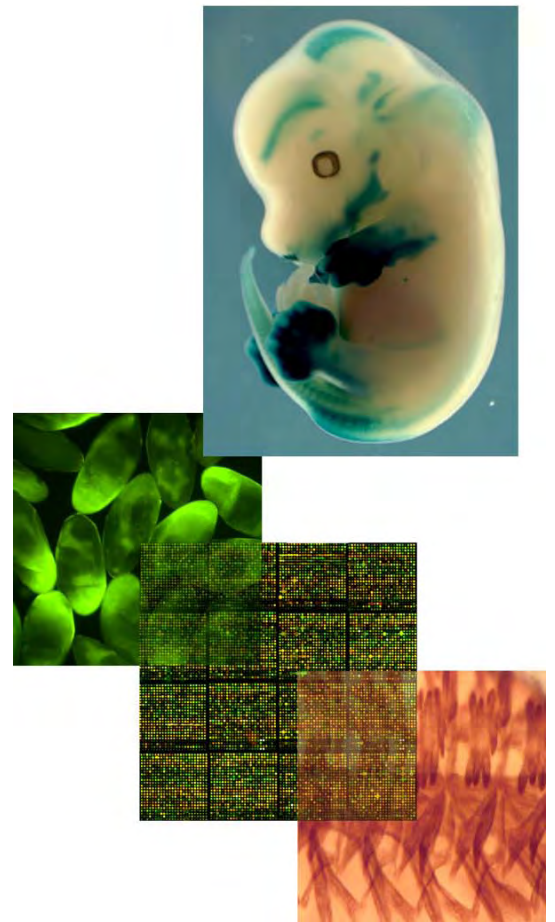
The central issue in developmental biology is how from a single cell (the fertilized o-ovum) complex cellular networks are formed that finally can give rise to the highest levels of organismic complexity. Understanding the ways, how this fundamental biologic problem is solved by Nature is a topic of many projects of developmental biologists within the Heidelberg research community. Current research topics in Heidelberg include early pattern formation, the development of cell types and organ systems including the nervous system and plant development, the evolution of developmental mechanism, aging and senescence, and stem cells in developmental biology and medicine.

Many Heidelberg research groups are focused on the field of **pattern formation**, i.e. the communication between cells and

within cells. This is a central issue in developmental biology with major relations to quantitative and modeling approaches, and researchers from Heidelberg have made important contributions to this field. Extensive communication between cells is required despite the fact that the form of an organism is already preprogrammed in its DNA. Pathways of communication are mediated by signaling molecules, which are released by **signaling centers** that organize other cells within a tissue or an organism. Signaling centers play a fundamental role in **embryogenesis** and **regeneration**, and they are disturbed or miss-activated in many types of **cancer**. The origins of individual organ systems during development, **organogenesis**, also involves general rules that can be genetically dissected in various model systems. The-

se general rules form a conceptual framework and it is a challenge to model them on a theoretical level and to understand on the molecular level how they contribute to the origin of the many thousands of cell types that make up a complex organism. This promising twist between theory and experiment is a major topic of our new research groups **modeling** developmental processes. The developmental approach also opens new perspectives for classical fields in biology: Comparative genomics and the analyses of developmental mechanisms in a broad range of species from worms to human revealed the existence of basic developmental mechanisms and we begin to understand the **evolution** of organisms on mechanistic level. With the realization that our genome is far more plastic than previously suspected, such studies are also critical to understand the long-term outlook of our own species. But also the immense complexity of the nervous system gets unraveled: In the last years, it was found that during **neurogenesis** many of the molecules and mechanisms used in other organ systems also act in the formation of the nervous system.

Developmental biologists require and receive training in a broad spectrum of methods from molecular cell biology. Approaches and Methods include cellular and microscopic techniques (live cell imaging, fluorescence and confocal laser scanning microscopy, FRET and FRAP analyses), quantitative and spatial analysis of mRNA and proteins, techniques for the expression of gene products in embryos, microinjection, cell and tissue transplantation in embryos, whole-mount in situ hybridization, use of synthetic mRNA, promoter analysis, transgenesis, protein-protein and protein-DNA interactions, DNA foot-printing, mutagenesis screens, bioinformatics, modeling computational analysis based on spatial expression data and more.



Bachelor studies towards Developmental Biology

There are two Bachelor study programs in Biology in Heidelberg: *Biology* and *Molecular Cell Biology*. Both programs are suited for the Major program in *Developmental Biology*. Here we give students information about courses and lectures that are especially relevant for the study of Developmental Biology.

1st Year: The Basics

In the undergraduate lectures 1 and 2, students will be introduced to general biological concepts that every biologist must know: Cell biology, Systematic and Evolution. Of special importance for the study of Developmental Biology are the courses 'Zoology A + B'. Here students can learn how the different body plans have become increasingly more complex and powerful in the course of animal evolution, e.g. how the simple nervous of worms developed into the complicated human brain, or how appendages and other novelties did arise during evolution. The non-biological minor subjects will demand a great deal of time for students in the first year of study (Chemistry, Physics and Mathematics). For the study of Developmental Biology these subjects are important, because Developmental Biology is an interdisciplinary field of research. Students have to be chiefly familiar with Physical Chemistry and Chemistry in order to get a deeper understanding Biochemistry and Molecular Biology.

2nd Year: Introduction into the Molecular Biosciences

In the undergraduate lectures 3 + 4 students will be introduced to Biochemistry, Molecular Biology, Cell and Developmental Biology as well as Physiology of animals and plants. For these lectures for students should revise the subject with the help of textbooks. All subjects are of vital significance for any

study of Developmental Biology. The undergraduate course *Methods of Molecular Cell Biology* offers an introduction into the working methods of bioscience labs. Here students will learn fundamental skills for biochemical, molecular biological and microbiological work. In the undergraduate course *Experimental Physiology and Developmental Biology* students will conduct basic experiments in Neurobiology and Developmental Biology: students will study the unlimited regenerative capacities of freshwater polyps, the fertilization and early development of frogs, and the embryogenesis of a chicken.

3rd Year: Towards Development Biology

With the 'cycle lectures' relating to the topics *Molecular Cell Biology*, *Biochemistry* and *Molecular Biology*, students are invited to deepen their knowledge in fundamental subjects of molecular biosciences. The following cycle lecture is focused on Developmental Biology: *Cell Biology 4: Molecular Developmental Biology / Genetic Model Systems*. Here the students will get an introduction to genetic model systems where major discoveries in Developmental Biology have been made, e.g. the worm, the fly, the fish, the frog and the mouse. This lecture is followed in by a course (HP-F) entitled *Genetic Model Systems: Fish, Fly, Frog, Mouse and Polyp*. This course will introduce the beauty and strength of the various genetic model systems used in Developmental Biology today. The course will be accompanied by a seminar introducing the latest literature. Both, the lecture and the course are required to enter the Major program in Developmental biology, although students are encouraged to hear other lectures or participate in other courses and seminars. In the 3rd year students should also take the opportunity to get to know developmental biology in work groups in **main courses** (3 weeks full time). Here, 3rd year students can find 'their work group', in which they would like to carry out the Bachelor thesis.

Master Developmental Biology

Students can choose one preferred major in our Master study program. Teaching language will be English and eight Majors are offered in 2007/08:

Cancer Biology

Developmental Biology

Evolution and Ecology

Infectious Diseases

Molecular and Cellular Biology

Mol., Cell. & Dev. Biology of Plants

Neuroscience

Systems Biology.

Our study program will offer students optimal conditions to access graduate programs in their relevant research areas. The regular time for the Master study program are two years and leads to the degree **MSc Molecular Bioscience, Major Developmental Biology**. It should be emphasized that the program is organized in a way that eager students can also pass it in only 3 semesters so that they can enter PhD study program earlier.

Admission. European students can apply until the 15th of July 2007 for a place in the major Developmental Biology. For Non-European applicants there is an extra application procedure starting at the 15th of April. We recommend that you choose an additional major in case Developmental Biology is overbooked. In each major program a ranked list of applicants will be compile according to three selection criteria: Academic results for Bachelor Degree (max. 15 points), special qualifications (max. 15 points), result of a selection interview (max. 30 points).

Approval notifications will be sent out by the end of August. The course of study will commence with the beginning of the winter semester 2007/2008, starting October 1st.

1st Semester: Frontiers in Biosciences

The Masters Degree consists of seven modules, which students can complete in 3-4 semesters. The first two modules are part of

the course for all Masters students: *Frontiers in Biosciences 1 and 2*.

Each module is made up of lectures and tutorials as well as a course (three weeks) with an accompanying seminar. The lecturers who take these modules also offer the major modules in 2nd - 4th semester. Students in Developmental Biology choose an accompanying course and seminars strengthening and deepening their knowledge in Molecular Biology and Cell Biology with a focus on methods required for Developmental Biology. We offer two courses *Advanced Molecular Biology for Developmental Biologists (RNA Techniques)* and *Advanced Biochemistry for Developmental Biologists (Recombinant Protein in Bacterial and Eukaryotic Expression Systems)*. These courses are necessary to get familiar with a number of fundamental techniques frequently used in the analysis of developmental processes, e.g. the injection of synthetic RNA into eggs and embryos or the expression of recombinant signalling molecules in eukaryotic expression systems

2nd Semester: Focus Biosciences

Two modules in second semester offer an intensive program in modern Developmental Biology. The two modules *Focus Biosciences 1 and 2* provide a broad program that deals with Developmental Biology from the level of molecules and cells to the level of whole organisms. It includes lectures, tutorials, courses and seminars. The **courses** are organized in such a manner that students will get familiar with a broad spectrum of methods used in Developmental Biology, e.g. advanced life cell imaging technology (confocal and 2-photon laser scanning microscopy, FRET and FRAP analyses), techniques for the expression of gene products in embryos, promoter analysis, transgenesis, protein-protein and protein-DNA interactions, bioinformatics, image analysis, and modeling approaches. We will also offer a course on the evolution of developmental mechanisms (Laboratoire Arago of the CNRS and Université Pierre et Marie Curie (Paris) in Banyuls-sur-mer) as well as courses on human genetics, i.e. on mammalian fertilization and on the importance of developmental mutations in human diseases. In our **lectures** we will give an

overview on the genetic and epigenetic mechanisms in the regulation of development as well as on the molecular mechanisms of stem cell differentiation in normal development and cancer.

3rd Semester: Modul Biolab, Working in Developmental Biology

The modules in the 3rd semester are **lab courses** where students work for six weeks in labs of one of the Developmental Biology work groups. In the Developmental Biology program a broad spectrum of groups from various research institutions (i.e. Institute for Zoology, the EMBL, the DKFZ, and the Forschungszentrum Karlsruhe) offer such lab courses. Here students can make their final decision in which group they actually want to work on their Master thesis. Students can complete these courses in parallel with the second semester modules and therefore can even skip one semester.

As part of the general program, students can

also participate in a LSH program (Life Science for Health) offering a structured overseas residence in 3rd semester. In this program, students completing a Masters degree in 'Molecular Biosciences' can attend courses/modules at the Leiden University Medical Centre (Leiden, Holland) or the Karolinska Institute (Stockholm, Sweden).

4th semester: Master thesis

The module 'Masters Thesis' consists of a research project for six months in which students undertake experimental work and complete a thesis on a project in Developmental Biology. Students can choose any Developmental Biology research group participating in this program (i.e. Institute for Zoology, the EMBL, the DKFZ, and the Forschungszentrum Karlsruhe). The Masters Degree finishes with the disputation. Here students define their research proposal, present their research results, and interpret their outcomes. With the completion of the disputation students receive the academic result '**Masters of Biosciences/Major: Developmental Biology**'.

1 st	Modul 1 Frontiers in Biosciences	Modul 2 Frontiers in Biosciences
	Advanced Molecular Biology 5 weeks lecture & tutorials 15 CP RNA Techniques 3 weeks lab course	Advanced Molecular Biology 15 CP 5 weeks lecture & tutorials Protein Expression Systems 3 weeks lab course
2 nd	Modul 3 Focus Biosciences	Modul 4 Focus Biosciences
	Advanced Developmental Biology 15 CP 5 weeks lecture & tutorials Gain and loss of function analysis in model systems 3 weeks lab course & seminar	Genetic and Epigenetic Mechanisms 15 CP 5 weeks lecture & tutorials Bioinformatics and Microscopy <i>or</i> Mammalian Fertilisation <i>or</i> Experimental Embryology <i>or</i> Development and Disease 3 weeks lab course & seminar
3 rd	Modul 5 Biolab	Modul 6 Biolab
	Working in Developmental Biology 15 CP 6 weeks lab course in a DB work group <i>or</i> Structured stay abroad	Working in Developmental Biology 15 CP 6 weeks lab course in a DB work group <i>or</i> Structured stay abroad
4 th	Master thesis 30 CP 6 months in a Developmental Biology work group	

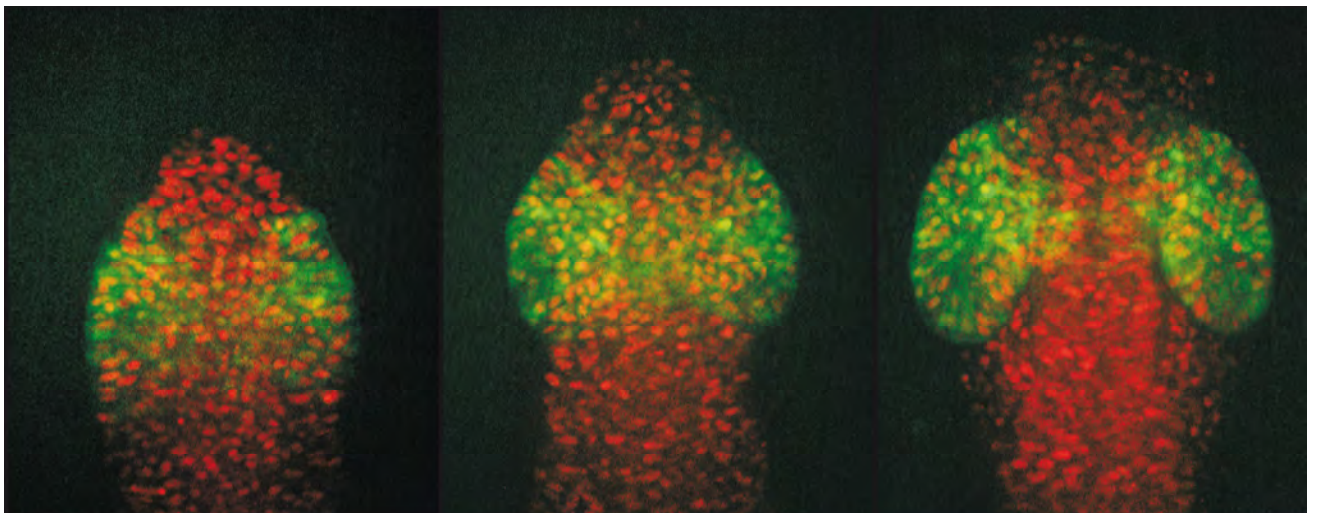
PhD Developmental Biology

Doing a PhD in Developmental Biology is an excellent entry into your scientific career. Completion of a doctorate takes 3 years and is organized as a graduate program (PhD program). The most important part of this program is the research project that each student undertakes independently in research group renown for its work in Developmental Biology. Each student will be allocated a thesis advisory committee (TAC) with the project leader and three further independent group leaders. Students are also offered a program of lectures, seminars and courses to further their understanding of relevant methods and concepts. Students will also have the chance to present their research results at international conferences and meet developmental biologists from other countries.

The Heidelberg research groups working in the field of Developmental Biology provide PhD students with numerous options. The faculties for Biosciences and Medicine and other non-university research centers (MPI, EMBL, and DKFZ) offer comprehensive research approaches in Developmental Biology. The areas of research range from DNA-Protein interactions to the analysis of complex regulatory networks. Students can choose any of these areas to qualify themselves for a scientific career.

Commencement of a PhD. During the Masters Degree students will be kept informed by their lecturers on potential PhD projects and options available in their respective research groups. Students are advised to discuss plans for a PhD with their lecturers as soon as possible, because it can take up to 10 months to organize personnel in the research groups. Currently the prerequisite for acceptance into the PhD is the successful completion of a Masters degree. However, efforts are being made to shorten the time from Bachelor Degree to PhD. The aim is to offer a one year postgraduate course. This year will correspond with the first two semesters of the Masters Degree. After this year students should then be able to directly change to the graduate program. This path is as yet not available. For information about the current rules please refer to the faculty PhD Website.

And the future? As Developmental Biology Post Doc, you have an excellent opportunity to work in many labs worldwide. Developmental Biology is the fastest growing biological discipline in the last 10-20 years. You can judge this by checking the frequency and size of international conferences with topics from Developmental Biology. Developmental Biology is not only the Science to understand embryology and cell differentiation, it is also the basic science to understand human cancer, aging and a prerequisite for regenerative medicine. The job market in this research area is therefore excellent.





People

Developmental Biology



Akhtar Group / Mechanisms of transcription regulation through chromatin / EMBL



Arendt Group / Evolution of gastrulation and central nervous systems in Bilateria / EMBL



Buselmaier Group / Human genetics / Human Genetics



Davidson Group / Biochemistry of Wnt signaling / DKFZ

Furlong Group / Regulatory networks required for tissue development / EMBL



Grosshans Group / Drosophila cell cycle regulation and cellularisation / ZMBH



Holstein Group / Signaling centers and the evolution of body axes / HIZ

Liebel Group / Gene expression / FZK



Loosli Group / Medaka organogenesis / FZK

Lyko Group / Epigenetics / DKFZ

Müller Group / Mechanisms of transcriptional regulation in development / EMBL

Niehrs Group / Molecular analysis of the Organizer in vertebrates / DKFZ

Özbek Group / Biochemistry of the ECM and Wnts / HIZ

Petersen Group / DNA binding proteins and molecular chaperones / HIZ

Rappold Group / Homeodomain transcription factors / Human Genetics

Spitz Group / Genome architecture and vertebrate development / EMBL

Steinbeisser Group / Signal transduction in the early vertebrate embryo / Human Genetics

Strähle Group / Genetics of vertebrate nervous system and muscle development / FZK

Vogt Group / Genetics of human germ cells and fertilisation / Human Genetics

Wittbrodt Group / Brain patterning and eye development / EMBL / HIZ



Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft



DEUTSCHES
KREBSFORSCHUNGSZENTRUM
IN DER HELMHOLTZ-GEMEINSCHAFT

RUPRECHT-KARLS-UNIVERSITÄT
HEIDELBERG

