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Notes on the Status and Teaching of Vertebrate Comparative Anatomy and Embryology in European Universities

Karl E. Goellner

Abstract. During six months in Europe and Great Britain inquiry was made at 35 universities as to the status of vertebrate comparative anatomy and embryology in undergraduate curricula. People directly involved in teaching these courses were interviewed. Wide variation in programs was found, with evidence of a de-emphasis of morphology in many institutions.

It seems a reasonable assumption that vertebrate comparative anatomy and vertebrate embryology are standard courses in American college and university curricula, judging by the number of good textbooks and laboratory manuals available, from conversations with teachers, and from reading most college catalogs. On the other hand, that these courses are not as firmly established as formerly is indicated, for instance, by the absence of comparative anatomy from the entrance requirements of the University of Iowa College of Medicine in recent years, and the absence of clear-cut comparative anatomy and embryology courses in recent catalogs from Harvard and Johns Hopkins. Further evidence of change, at least, is the appearance in recent years of texts and laboratory guides presenting the subject matter of both comparative anatomy and embryology in a single, integrated account. No doubt the swing toward modern, or molecular, biology, and the need for new courses in the zoology curriculum have something to do with these changes.

From June to December, 1965, we used a sabbatical leave to travel in Western Europe. Among other things, a major objective was to inquire into the present standing of comparative vertebrate anatomy in the undergraduate programs of some leading universities. When possible we inquired also about the status of vertebrate embryology. The itinerary was planned, so far as possible, to permit visits in each country when its universities were in session. That is, we started in West Germany in July before those institutions closed for summer; we passed through Switzerland and spent early August in Italy and Austria. By September we were in Scandinavia and Denmark, where the universities were getting under way. Holland was visited in late September, England and Scotland in October, and Germany re-visited in November, when the German universities reopen for winter term, or semester. A total of 35 university departments

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of zoology, or anatomy, and three research institutions were visited, as follows (alphabetically):


Holland (4): Amsterdam, Gröningen, Leyden, Utrecht, and the Hubrecht Laboratory for Developmental Biology.


Norway (2): Bergen and Oslo.

Switzerland (2): Basel and Zurich.

Austria: Graz.

Denmark: Copenhagen and the Marine Laboratory at Helsingöre.

(Italy: Padua, briefly)

The overall selection of countries was dependent in part upon the language spoken. We could speak only English and German, otherwise French and Belgian institutions might have been included. The visit at Padua, in Italy, could have been longer and more productive, but our host spoke imperfect German, and we spoke no Italian. Interviews were arranged after arrival in the city, sometimes within moments in the man's office, sometimes for the next day, over the telephone. In all cases we tried to talk directly with someone actually involved in the teaching of anatomy and/or embryology to undergraduate students. To promote informality and frankness on the part of those interviewed, we did not conspicuously "take notes". Rather we chatted "man to man" about the subject matter and trends of vertebrate zoology, comparative anatomy and embryology in particular, and we made up notes afterward. Because of this and the language problem, in some cases, and because of the variations in length of visits, in the personalities of those interviewed, and in the degree of local interest in these topics, the notes are not uniform and do not lend themselves to tabular form. Therefore, the data are presented in a summary fashion for each of the countries, and although the universities are named, the professors interviewed are not named. (These can be supplied upon request.)

DENMARK

Here we saw a fine new Anatomical Institute in an all new university campus. Comparative vertebrate anatomy is given in the fourth year, as an advanced course, for zoology majors.
Premedical students do not take comparative anatomy. Background for the course includes two years of general zoology, half lecture, half laboratory. The course itself consists of lectures and demonstrations, no laboratory. In any given year, emphasis is placed on selected organ systems, such as the nervous and endocrine systems. Another year it may be skeletal and muscular systems. Enrollment is about 25. We were impressed with the candor and friendliness and informality, and were guests at a staff meeting over coffee and sweet rolls.

At Helsingør, on the island of Zealand, just across the Oresund from Sweden, we spent a half day at the Danish Marine Biological Laboratory, where extensive researches are proceeding in systematics, physiology, behavior and embryology of marine vertebrates and invertebrates. Facilities, including library, aquarium, living quarters, and research vessel are all excellent, the building having been converted after World War II from a German submarine base.

Norway

Two different institutions were seen, the more cosmopolitan university at Oslo, with a new campus and fairly modern but already outgrown building; and the smaller one at Bergen, on the west coast. At Oslo, comparative anatomy is a part of Zoology 3, taken in the second year, more or less simultaneously with Zoology 2 which is largely systematics. Out of 60 hours lecture and 60 hours laboratory time for Zoology 3, comparative anatomy gets approximately 20 lectures and 22 hours of laboratory. Embryology is included, with ten lectures and eight hours laboratory. Class size is roughly 24 to 32. Much fresh or frozen material is used, such as Myxine, sharks, rats, pig heads. Students are expected to handle English and German. Texts include those of Romer2 and of Huettner, also some German texts. Zoology 3 includes also cytology and genetics.

At Bergen the department is smaller, with close teacher-student relationships. Comparative anatomy and embryology are taught as parts of general zoology, for zoologists, not for premedical students. Classes are small, 36 or fewer in lecture, 16 to 18 in laboratory, with two instructors in the room. The general zoology consists of 60 hours lecture and 52 hours of laboratory; the second half of this course is largely vertebrate zoology, comparative anatomy and embryology. Each system is taken up separately in lectures; dissection is by animal types, again using fresh or frozen material. They are proud of the Sars tradition at Bergen—father, Michael Sars, and son, G. O. Sars. System-
atics and faunistics are strong, and are taught at the museum; marine zoology is taught at the marine station. American and English texts are used.

**SWEDEN**

At Göteborg, vertebrate morphology, including embryology and organogenesis, is included in the second half of the general zoology course, the pattern apparently more like that in West Germany, with students in the laboratory daily from 8 to 5 p.m., with several, “five-to-eight”, lectures interspersed during the day. A new building is planned.

Stockholm has a new building for its Institute for Zoology on a new campus outside the main city. Here, too, comparative vertebrate anatomy is given in general zoology all day, daily, for the second of two semesters. Lectures, “two or three a day”, are interspersed with dissection. The course starts in the fall with insects, then covers general invertebrate zoology. Fishery biology, including basic statistics, is included and given some emphasis. Comparative anatomy as such is not considered a strong course any more; rather they are trying to emphasize functional zoology, biochemistry, physiology. Romer's texts are used in English; also, other American textbooks are used. I was told they had had the “German system” until about ten years ago, when they changed to the “American system”, and like it better. (???)

At Uppsala, made famous for most of us by Linnaeus, comparative anatomy is also given in the second semester of the general zoology course. This includes also vertebrate embryology, which gets ten lectures with laboratories in two days. I was told that the curriculum was in flux; whereas formerly they offered two years in basic zoology, now they have only one year. The shift is definitely away from classical zoology, morphology, and taxonomy, toward modern, molecular biology. We saw a number of Linnaeus' type specimens there, in the museum, and we enjoyed a visit to the famous Linnaeus Garden in the city, where many of the plants he named are kept in culture.

**HOLLAND**

The Zoological Institute of the university in Amsterdam is located literally in the edge of the large municipal zoo, making handy access to large animals, especially exotics from the Tropics and the Orient. Comparative anatomy is given for zoology majors in classes of about 50, but not to premedical students. Most of the usual types of animals are studied and dissected, but the dog, as a mammal, is given special attention and con-
considerable extra time in the laboratory. Embryology is given only incidental attention.

At Groningen, an extensive building program is under way to provide a grand new biology center of several buildings, outside of the city, in a new science campus. Medical students do not come through the program. Emphasis is given to behavioral studies, but physiology, endocrinology, and ecology are also strong. Morphology and embryology are part of the undergraduate program, but advanced work is not encouraged here. The first year student gets six hours of lecture per week in embryology, morphology, ethology, and physiology, plus two half days per week of laboratory in morphology of vertebrates one year, invertebrates in alternate years, along with botany, physics, chemistry, mathematics, and geology. In his second year he drops the mathematics and physics, and adds one half day per week for histology and cytology. The third year consists mainly of all day laboratories, five weeks of ethology, five weeks physiology, two weeks histology, three weeks genetics (lab and ten lectures) and five weeks in microbiology. A very large collection of living animals ranging from insects to turkeys and reptiles gave evidence of strong interest in ethology, in the Tinbergen tradition.

The Zoological Institute at 450-year-old Leyden University occupies a fine new building, comprising a six-floor tower for research and offices, and a three-floor laboratory for teaching and for the department of physiology. Morphology, ethology, and physiology are strong here. All biologists take comparative anatomy (presumably as general zoology) in the first two years. Class sizes average about 50 to 60 each year. Premedical students, about 300 each year, take the vertebrate morphology part of this course, then a condensed laboratory in the second year, in a room seating 100 to 120 at a time. Vertebrate anatomy is included in two hours of lectures each week for 26 weeks by the Institute Director, followed by a vertebrate morphology laboratory of 26 afternoons concentrated in five weeks of September and October of the second fall. The second year includes also one hour lecture a week by the Director. Texts are English and Dutch; for embryology, the new Balinsky seemed to be favored.

In Utrecht, through a curious chain of misunderstanding, I was directed from the zoology department or institute, to the medical school, then to the veterinary school, presumably because I had emphasized vertebrate anatomy in my inquiry! Having lost much time, I visited there, was warmly received, and saw a laboratory crowded full of 90 students doing pig embryology from slides. What I saw and heard impressed me that they were getting a strong embryology course. I was told that
the staff wanted to build a strong general vertebrate zoology program into the veterinary curriculum. As expected, dissection in morphology concentrated on the horse, dog, and goat.

Rather than going back into the city traffic to the zoology department, we chose to go on to the Hubrecht Laboratory for Developmental Biology. Here too, a new campus is being planned and built in the country outside of Utrecht. Excellent facilities, including animal house, greenhouses, aquaria, eleven climate control rooms, electron microscope, a rich library of journals and reprints, and permanent collection of slides and specimens, are provided for visiting international teams of investigators. Developmental genetics, developmental physiology, tissue and organ culture, and other areas may be pursued by qualified persons in the best of research environments.

ENGLAND

Among the five British universities visited, there is wide diversity and much flux, as shown briefly below. At University College of London University, comparative anatomy has declined in importance since the days of D.M.S. Watson, though the students in the three year B.S. program do get some anatomy in general zoology, and will have read much in Romer's texts, including paleontology, also a variety of other recommended, but not assigned, books. The program is "in flux", tending perhaps "toward the American system", to allow students to postpone specialization a little longer. The medical students get comparative anatomy and embryology, as such, only in high school. At Oxford, the zoology students, or most of them, get now only 24 lectures and two-hour laboratories, as compared with the 85 to 90 half days they used to get. In embryology, causation and experiment are stressed, with very little descriptive embryology. Medical students do not come through the program. There is some feeling the pendulum has swung too far.

At Sheffield, comparative anatomy is given for 14 weeks in 42 lectures and 28 two-hour laboratories. Embryology is treated in 12 lectures and eight laboratories. These are required of zoology majors but not of premedical students. The usual animal types are dissected, and standard embryological stages studied, but much of the large osteological collection and preserved material has been pushed aside to make room for the equipment needed in the newer courses, such as endocrinology and physiology. The descriptive embryology will be altered to experimental embryology soon, it is hoped.

In the new program at Durham, I was told, the beginning zoology majors get only a few lectures, perhaps six, on the grand broad patterns in the vertebrates. Physiology and ec-
ology are emphasized. "Why dissect *anything* now?" I was asked. Each lecturer in the general course does a group or two, expanding on topics he prefers. These are tied together at the end by a few lectures on phylogeny, evolution, and paleontology. A few animals are dissected but *no* mammals.

Cambridge, too, was reported to be in a state of change. General and vertebrate zoology are being given for the last time in 1965-66, but it was not clear what changes would come about next year. Vertebrate morphology now receives about 10 lectures and 10 laboratories; vertebrate embryology has about the same time, but the content and time allotted will have to be "sharply cut and selected" next year. Two new courses are being attempted; one called "Cell Biology" is strictly molecular, and deals with DNA, submicroscopic and microscopic structure and function, and techniques. The other, "Biology of Organisms", deals with insects, fungi, and higher plants. The main laboratory is very large, seating 220, but usually has only 70 to 90 students at a time. Closed circuit TV has been installed and is being used with some success.

**Scotland**

The program at Edinburgh was perhaps the most abbreviated, that at St. Andrews the most unusual, that at Aberdeen the most traditional, and that at Glasgow in complete flux and review. At Edinburgh zoology students receive about half a dozen lectures in general anatomy the first year and up to 25 in the second year, with "some laboratory", but no emphasis, no details. Modern molecular biology is the theme. If students come from high school with chemistry, physics, and mathematics, "it doesn't matter if they have had *any* biology." Some modern American texts were described as "not bad" but of little interest in their program. For embryology, I was sent to the Bureau of Animal Genetics, where just enough descriptive embryology is taught to give background for the main course in experimental embryology. The pendulum may have swung too far, for "My God, they don't know one animal from another, they don't know one organ from another, and they don't know how to cut sections!" one teacher exclaimed!

Zoology at St. Andrews has a strong neurophysiological theme. Students do get about a term of vertebrate zoology in their first year, including dissections of standard types, and lectures by systems, each lecturer emphasizing any theme or direction he chooses. This is part of the background for the second year, for which the following schedule was posted:

**October 11**  Nerve-muscle physiology, 1 month
November 8 Protochordates; anatomy and classification, 1 week
November 15 Cyclostomes and Fish, 2 weeks
November 29 Amphibia and Histology, including technique, 2 weeks

Winter (Candlemas) Term:
January 11 Genetics and Cytology, 4-5 weeks
February 21 Reptiles and Birds, 4-5 weeks

Spring (Whitsunday) Term:
April 12 Neurosecretion, 1 week
April 18 Endocrinology, 2 weeks
May 2 Mammals and Evolution

At Aberdeen, Zoology 2 is essentially comparative vertebrate anatomy, with 30 lectures and five laboratories per week in the second and third terms. Texts by Young and by Romer are the main references. The American “integrated texts” were known, but “there is no course to fit them!” Vertebrate embryology is essentially descriptive and comparative, but merits only 10 lectures and 10 laboratories of three hours. A new course in advanced developmental biology is being planned, and both anatomy and embryology are being adjusted to today’s needs.

New leadership at Glasgow has brought a period of restudy and re-evaluation of all courses and programs in the hope of retaining the best of the old to go with the essential new areas. Everything was under discussion and debate, but it was suggested tentatively that perhaps they would offer a two-year required course in general zoology, covering all groups—some anatomy, some physiology, embryology, systematics, genetics, cytology, and ecology. This would be followed by two years of optional course combinations, perhaps two each year, studied in depth, and some research, with thesis, in the fourth year. Nothing was definite yet.

SWITZERLAND

At Basel, the Zoology Institute occupies the oldest building on the campus, dating from 1462, right on the bank of the Rhine River. It was very well renovated in 1962 to celebrate its 500 Jahrfest. Comparative anatomy is obligatory for biologists and for premedical students, who take it in the Summer Semester, April to July, for about twenty weeks. There are approximately 280 students in the lectures, one hour daily, Monday through Saturday, or roughly 110 - 120 lectures per term. The laboratory (called “Kursus” or Prakticum”) is separate, in the second Summer Semester, a year later. Only about 40 students take the Prakticum, for two half days a week. They study examples of...
all the chordates, first in a survey, then by systems, with emphasis on selected topics, such as skeleton, or nervous system. A special feature is a program of demonstrations, four times per semester, three days each, in which the laboratory is open all day for study and examination of many demonstrations, dissections, dry and wet mounts, models, etc. Emphasis is on basic principles, beyond which students may dig more deeply for themselves. The textbook is in German, by the Institute Director. Vertebrate embryology comes in the Winter Semester of the first year as part of general zoology. Of the 24 weeks in the Winter Semester, only three weeks, five hours per week, are given to lectures in embryology. The Prakticum is optional in the Winter Semester of the second year, one afternoon of three hours per week. Both vertebrates and invertebrates are studied, with a limited number of groups, such as worms, or arthropods, being selected for emphasis each year. This may be followed, for a few students, by another Prakticum in the third Winter, one half day per week, in special analysis of form and development in selected topics, such as feathers, insect wings, etc. Embryology is not vertebrate embryology, but general embryology.

The university at Zurich is only about 100 years old. The Zoological Institute occupies a large building which also houses the museum and the botany department. Comparative anatomy is part of general zoology, covering both invertebrates and vertebrates. Lectures are given five hours per week for 25 weeks, each semester, with a two-hour laboratory (Prakticum) per week. All zoologists and premedical students take this. The zoologists then have three semesters of Voll Prakticum, five days a week, all day; of this, half of one semester is given to vertebrate comparative anatomy, in which all major groups are studied and dissected. This Prakticum is given in one large laboratory, in two sections of 180 students each. It would seem that these two courses, the general and the advanced Prakticum, constitute a strong, obligatory program in anatomy. Embryology is treated in the general course, followed by a semester of lectures, two hours per week, in invertebrate development, another semester of vertebrate development, plus a separate one lecture per week on induction. These are followed by a Prakticum of three hours per week, one semester, of experimental embryology. The syllabus for this indicated it was a strong, advanced course.

AUSTRIA

The old university at Graz was closed in late August, but I was fortunate to find the right people. As might be expected, the
pattern of courses resembled those in the German universities. Zoology students, but not medical students, take a general zoology course of five lectures per week in their first winter semester, then a "Zootomical Prakticum" (i.e., techniques) one afternoon per week in the summer term. These are followed by the Grossprakticum (laboratory), daily, all day, 8 a.m. to 6 p.m., for the next two semesters. Later they get also another semester of five lectures weekly in vertebrate comparative anatomy. Some embryology comes into all these courses, and there is also a lecture course every other year. (It is worth mentioning that the zoology majors are offered every two years a two-week marine biology course at Rovinia on the Yugoslavian coast, and, in alternate years, a two-week limnology course at Lund, Sweden. These are required courses.)

WEST GERMANY

The German universities seem to vary less, and to have departed less from their old traditions, in comparative anatomy and embryology, but emphasis in a department or institute depends very much on the interests of the director or chief. Typically there is a strong general zoology course (Allgemeine Zoologie), with often two semesters of daily, all-day laboratories (Grossprakticum) followed by one or more special vertebrate anatomy courses, primarily lectures. My first visit (first of the entire trip) was at Göttingen, at the imposing new Anatomical Institute. Here in a very cordial atmosphere I was given to understand that comparative anatomy in Germany was passé, the days of Gegenbaur long gone! Emphasis here was on human anatomy for medical students, and especially on human development. A magnificent museum hall of large models of human embryos and fetal stages is being completed for teaching and research.

Quite by chance, we also visited the university's Institute for Jagdkunde (Hunting Science) at Hannover-Münden. Space does not permit description of this unique center for research in game management and hunting arts, somewhat comparable with our Wildlife Research Units, as at Ames. Our guide was an American Fulbright post-doctoral student from Syracuse.

At Erlangen, after 26 weeks, two semesters, of general zoology and two semesters of daily, all-day zoology laboratory (prakticum), there is required a semester of two lectures and eight laboratory hours of vertebrate comparative anatomy. A separate optional semester of embryology lectures and laboratory is offered, but this includes as much invertebrate as vertebrate embryology. Medical students take the general zoology lectures, but not the laboratories.
A strong course in comparative anatomy is taught following general zoology at Frankfurt, and there is a close tie between zoology and medicine, but the interview was unsatisfactory and my notes regrettably incomplete. Vertebrate embryology is also given emphasis. Much teaching material and equipment has had to be replaced after heavy war damage. German texts and American texts in translation are used.

In Freiburg, after a semester of lectures and another of laboratory in general zoology for both zoologists and medical students, the zoologists are required to take the full Grossprakticum, in which standard chordates from each major group are studied in addition to selected invertebrates. Embryology is given to only a limited number of zoologists in alternate years, in the form of a Grossprakticum, eight hours a day, five days per week. Weismann and Spemann set the tradition here.

The program at Giessen consisted mainly of the strong general zoology course with Grossprakticum for both zoologists and medical students. Vertebrate anatomy and embryology have been given but not emphasized. With a change in the directorship of the institute this year, emphasis may be shifted toward vertebrates, or not, depending on whom they select. The old building suffered heavy bomb damage but has been restored.

Likewise at Heidelberg, oldest university in Germany, in a new modern building outside the crowded campus in the old city, emphasis is on the strong general course in which vertebrates are taken up for five weeks in the second semester. The lectures are for zoologists and medical students, the Prakticum only for zoologists. Embryology is not given as a separate course, but will be as the department expands into its new quarters.

The Zoological Institute at Kiel is in an old building with the museum, near the harbor, and cramped for space inside and out. A new modern building is being planned. Vertebrates are taken up in the second semester of the general course for zoologists. There is a separate “principles” course of lectures for biologists, medical students, and geologists. The zoologists follow with the daily Grossprakticum. There is also a comparative embryology course of two lectures per week, one semester each for invertebrates and vertebrates, with no laboratory.

The main course at Mainz is the general zoology with Grossprakticum, strongly recommended but not required for future zoologists, teachers, and medical students. Dissection is not emphasized as much as careful study of demonstrations with much drawing of figures. At Marburg, comparative functional anatomy of chordates is taught in alternate years after the general
zoology. Medical students take only the lectures of the general course. Then chordate anatomy is given as three lectures per week in the winter semester, and one three-hour laboratory per week in the summer semester. Embryology is given as a strong separate course, with emphasis on causation and analysis rather than description.

Vertebrate zoology—morphology, physiology, embryology, etc. —is given one semester of a four-semester cycle in general zoology at Munich. The three lectures each week emphasize physiology more than morphology, and there is only one laboratory per week, for five hours. The laboratory room is full to overflowing. Texts are by Romer, in German. Vertebrate embryology consists of one lecture per week for 13 weeks, and two two-hour laboratories per week, in alternate years. Using books by Pat­ten, students study amphibian, fish, and chick early development and organogenesis. Medical students take only the general course lectures.

At Tübingen the basic course is general zoology with Grossprakticum for all zoologists, five days per week for one semester. Then follows a second Grossprakticum in vertebrate comparative anatomy, using Walker's guide for dissection. Three terms of embryology are offered, one of them treating vertebrates, but none includes laboratory.

At Würzburg, general zoology includes a short Prakticum of four hours per week in the second semester, but only three or four afternoons are given to vertebrates. Every third year a course of four lectures per week in vertebrate comparative anatomy is given without laboratory. There is also a lecture course in embryology to follow what is included in general zoology.

**Discussion**

The variety of programs encountered, ranging from courses with two terms of daily, all-day laboratories and perhaps more than 100 lectures to courses with very limited laboratory and lecture schedules, is difficult to evaluate or to compare with any program known, or assumed, in this country. Perhaps it does not make sense to look for uniformity among institutions of countries still jealous of their differences, but even within each country there is surprising variation. In West Germany, Austria, Switzerland, and in Scandinavia, thorough training in morphology is still considered fundamental for zoologists, often also for medical students. But there are signs of change toward reducing the time allotted for these courses. In Great Britain, variety prevails with a strong shift in some institutions away from the traditional or classical zoology toward the modern. Others are in transition and self-study as they try to modernize.
"Why dissect anything now?", I was asked. Yet, some sincere people fear the shift may already have gone too far. The Dutch seem to be somewhere in between.

Anatomy and embryology are generally "integrated" in the strong general zoology courses, but hardly in the way attempted for vertebrates in some of our schools. Beyond the first year, embryology may get serious separate treatment, or not, depending upon who is available to teach it, or upon the main interests of the director or department head. The influence of the director on the over-all zoology program seems most evident in the German institutes of zoology or anatomy (Consolazio, 1961). In no case did I find a basic biology course, integrating the fundamentals common to both botany and zoology.

No doubt comparison and evaluation would be easier if we were sure what the "American system" is, or even if there is such a thing as an American system. I believe it would be interesting and worthwhile to undertake a simple survey, perhaps by mail since communication is no problem, of a reasonable number of American colleges and universities to learn what is going on at the undergraduate level in comparative anatomy and embryology, and what status such courses have today.

**Literature Cited**