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Die Universitätslehrgänge „Pädagogik und Fachdidaktik für LehrerInnen“ (PFL) sind interdisziplinäre Lehrerfortbildungsprogramme der Abteilung „Schule und gesellschaftliches Lernen“ des IFF. Die Durchführung der Lehrgänge erfolgt mit Unterstützung von BMUkA und BMWV.

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1. Introduction: Becoming interested in content-based instruction

In May 1995 when I started to attend an M.A. course in Vienna, run by the City College of New York, I was first introduced to the idea of ”teaching language through content”. Content, in this interpretation, is the use of subject matter for second language teaching purposes. The goal of content-based second language instruction is to prepare second language students for the types of academic tasks they will encounter at university. As many academic books are written in English, content-based second language instruction provides students with opportunities for meaningful use of the academic language needed for study. We learned about the different models of content-based instruction such as

(1) *Immersion Education* (Students receive the majority of their schooling through the medium of their second language.)

(2) *Content Enriched Foreign Language in the Elementary School* (”Travelling” language teachers meet with elementary school children several times per week for instruction in the foreign language. For example terms on structures for describing weather are not presented in isolation but rather are coordinated with a science unit on metereology.)

(3) *Theme-Based Model* (Selected Topics or themes provide the topic for the ESL / EFL class.)

(4) *Sheltered Model* (Second language students are separated from native speakers of the target language for the purpose of content instruction.)

(5) *Adjunct Model* (Students are enrolled in a language class and a content course. The language class becomes content-based in the sense that the students’ needs in the content class dictate the activities in the language class.)

Teaching English and biology at a grammar school, I became very interested in the idea of teaching biology in English. I selected a very good class, 8th form language-orientated, for ”my project”. We started out watching an English film about DNA and genetics I had recorded in the summer holidays and I didn’t have a German film. To my surprise the students were very keen on ”testing” and applying their English knowledge and they were very willing to receive some instruction in English. As it was a language-orientated class, most of them (apart from two girls) were much more motivated by the use of English in their biology lessons. When I wanted to choose content-based instruction for my thesis, I was told that I would have to get the permission of the superintendent and so I decided to write about a different topic instead. Nevertheless, I didn’t abandon the idea of content-based instruction. Whenever there was the chance I opted for this mode of instruction, for example in English in the sixth form drugs are discussed and my class got a detailed biological background covering the body anatomy, respiratory system, illnesses, chemicals, and a lot more. After watching the film Philadelphia another class had to learn about AIDS, viruses in general, bacteria and parasites. In the meantime most of my students from the 5th to the 8th form are used to getting some biology instruction in English.

In the course of teaching biology in English I realized that the role of the teacher is necessarily expanded. One especially important task is the selecting of an appropriate (manageable, interesting) material and to facilitate the students’ difficulties with a range of new specific terms. For me there has been a great difficulty in making a compromise between my requirements and approaches as a content teacher and at the same time being sensitized to my students’ language needs. What followed was a systematic planning of instruction through a variety of strategies and techniques. Another difficulty was the need for the development of appropriate materials. I realized that the teaching in content-based instruction has to be much more student-centred to make up for the deficit in understanding. Moreover, the fear of the students of getting bad marks in exams due to poor English knowledge has to be taken and the relationship between the teacher and the students must be a friendly one. Having been faced with many new challenges I gladly seized the opportunity to enrole in the PFL-Lehrgang ”Englisch als Arbeitssprache” and I hoped to get a lot of advice and support for my future content-based teaching.

2. Coming home from the first PFL-seminar

2.1. Reactions from the teachers

On the first day back at school after the PFL-seminar my headmaster and some other teachers showed an exceptionally great interest in what we did at the seminar and what ”projects” I was planning to do in my classes. Especially one female biology colleague whose children I taught was eager to learn about my ”projects”. I taught her daughter, who was in the sixth form, in biology and her son, who is not so good at English, in biology and English in my third form. As two of her children were concerned, she worried a lot. She told me she wouldn’t mind English as a medium of instruction in biology in her daughter’s class, but in a third form she considered it to be much too early. She went on that giving so much attention to the acquisition of languages was a wrong development in education as all other subjects would lose importance. She pointed out that a lot of facts would get lost with the use of English in biology, that the students wouldn’t need the specific vocabulary in their English lessons. She feared that the general knowledge of the students would be badly affected. In any case students / parents should be allowed to choose this mode of instruction and it shouldn’t be forced upon them. At least it should only be done in language-orientated classes. Finally, after explaining to her that the marks of her children wouldn’t get worse, she put up with it and just said ”Naja, wir werden ja sehen.”

2.2. Attitudes of the students: The questionnaire

A little bit discouraged, but still strongly determined to go ahead with my project, I asked <u>all</u> my classes to describe their attitudes to biology instruction in English. I told them to write: Wenn ich Biologieunterricht in Englisch hätte, dann .... They should list the advantages, disadvantages, their worries, suggestions, topics they would like to deal with in English, whether they would like to do the project or not. Moreover, I wanted to know whether it would be different for them if <u>their</u> English teacher would teach them in biology or just <u>an</u> English teacher or a biology teacher. They answered the questions in German and didn’t have to write down their names. The students’ comments to the questionnaire were rather detailed and a great help for me to plan my future lessons. Here is a summary of the comments of class 6A. 19 questionnaires were handed in.

Wenn ich Biologie-Unterricht auf Englisch hätte, dann .... (Vorteile / Nachteile / gewünschte Themengebiete / Fach- versus Englischlehrer / Interesse ja/nein).

Advantages:

- Bereicherung für unsere Englischkenntnisse (13)
- Erweiterung des Wortschatzes (9)
- Unterricht wird lustiger, interessanter (8)
- Interessantere Stunden (6)
- Mehr Gelegenheit zum Englischsprechen (5)
- Viel Abwechslung (4)
- Man lernt "nebenbei" Fachvokabular (1)
- Vielleicht entsteht dann auch noch ein innigeres Verhältnis zur englischen Sprache (1)
- Mehr Spiele (1)
- Biologie lebt dann erst richtig auf, da Englisch eine besonders blumige Sprache ist (1)
- Praktischerer Unterricht (1)
- Heutzutage sicher nützlich, weil überall internationale Kontakte, sei es im Bereich Wirtschaft, Politik, Bildung (Auslandsaufenthalte von Studenten) und Kultur, geknüpft werden (1)
- Bessere Zusammenarbeit von Lehrern und Schülern (1)

Disadvantages:

- Weniger Verständnis (viele neue Vokabel) (9)
- Weniger Mitarbeit (4)
- Angst vor Fehlern (2)
- Angst vor Blamage (1)
- Prüfungen schwerer (1)
- Schüler, die Englisch nicht mögen, verlieren das Interesse an Biologie (1)
- Arbeitsaufwand für Lehrer und Schüler höher (1)
- Weiß nicht, ob das für die Sprachkenntnisse effektiv wäre (1)
- Mehr Vorteile für Englisch als für Biologie (1)

Comments:

- Möglichst einfache Vokabel, bitte!!! (4)
- Fachausdrücke auf deutsch übersetzen/erklären (3)
- Mehr Vorteile als Nachteile (3)
- Wäre aufregend, in manch' anderen Fächern auch so ein Projekt zu starten (3)
- Langsames Erlernen der Vokabel (Spiele) (1)
- Generell wäre es einen Versuch wert (1)
- Klassen sollten gefragt werden ---- gemeinsame Lösung finden (1)
- Schüler, die Probleme im Unterrichtsfach Englisch haben, sollten vorwiegend mit guten Englischschülern zusammenarbeiten - vor allem bei Gruppenarbeiten (1)
- Nicht ganzjährig (1)
- Stoff muß "fast genauso" wie auf deutsch verstanden werden können (1)
- Gemeinsame Einigung - Stoff/Prüfungen (1)
- Hilfe/Geduld bei Prüfungen (1)
- Thank you - we've got an English teacher (other class)
- Great! Let's start tomorrow! (1)

Suggested Topics:

Ethology (15)
The Sea (1)

Wolves (1)
Hormones (2)

<u>The same teacher in English and Biology:</u>

- Anderer Lehrer, da man sich sonst bemüht, ”gutes” Englisch zu sprechen - Vernachlässigung von BIU (9)
- Der weiß wenigstens, was wir in Englisch wissen (2)
- BIU-Unterricht kann durch E-Unterricht unterstützt werden (2)
- Hängt vom Lehrer ab (2)
- Englischlehrer macht weniger Fehler als der Biologielehrer (1)
- Bessere Erklärungen möglich (1)
- Kennen seinen Unterrichtsstil - mehr Vertrauen (1)

I was greatly relieved that the students were much less sceptical than I had feared. When I looked at the students’ questionnaires I only found three really negative remarks (”Thank you we’ve got an English teacher”) in altogether 142 questionnaires, completed in seven classes. The other students were willing to try out something new.

3. The classes

The questionnaires helped me to select two classes for my project. One class was 6A, a small language-orientated class. 17 girls and 3 boys attended this class. The students in this class were exceptionally diligent and had proven to be ideal for my projects. (I had done a feedback study with them, so they were familiar with questionnaires and ”experiments”.) Other teachers had chosen this class for other projects in Latin and maths. Moreover, I had taught 13 students out of 20 in their third and fourth forms in English and when I had had to give them up in the fifth form, I was not the only one who was very sad.
The other class was a third form. There were 27 students, 21 girls and 6 boys. This class was a weaker class and I chose them because it was the only class I taught in English and biology.
So the results aren’t completely comparable as the classes were rather different, but I hoped to get some guidelines anyway.

3.1. The ethology project in 6A and a visit of the headmaster

Over the Christmas holidays I took a lot of time to prepare a unit (15 lessons) on ethology, as the class preferred ethology to all other topics. Luckily, I had some English material at home and so I embarked on that endeavour. My efforts were greatly enhanced by the headmaster’s wish to join a lesson in this class. (I was allowed to choose the class and the lesson!)

3.1.1. The preparation of my lessons (see appendix)

I started out with the students writing a mindmap on animal behaviour while I showed them 10 different overhead transparencies (OHTs), which illustrated different fields/aspects of

animal behaviour such as *imprinting (Lorenz), feeding, mating, bonding, territories, aggression, social status, animal training (Sea World), cartoons (genes are being used as an excuse for bad behaviour)* (see appendix). I wrote some words on the blackboard and gave them my simplified and advanced versions of mindmaps to introduce them to the topic. Then we discussed the different OHTs together in class and I handed out a lot of sheets. I concentrated on the photo of the feeding of young birds and asked what would happen if the birds didn't have enough food for their young and introduced the concepts of the survival of the fittest (Darwin), siblicide and altruism. We also read an article from Science World to the topic. Later we differentiated between learned and innate behaviour. The final stage of the introductory lesson should be a kind of game. Each pair of students got one envelope in which were 15 different definitions of animal behaviour. Three were wrong and the students should find out which ones. The following lessons dealt with <u>Fixed Action Patterns (FAPs)</u> (bird songs, mating behaviour of stickleback fish, feeding, babies grasp strongly with their hands, women-men schemata, egg retrieving (graylag goose), brood parasitism). <u>Learning</u> was contrasted with FAPs. The following concepts were discussed: *maturation, habituation, imprinting, critical period, classical conditioning, operant conditioning, observational learning, play, insight and animal cognition*. *Rhythmic behaviours, animal movement (migrations - piloting, navigation, orientation)* were dealt with. The lessons covered a variety of topics in sociobiology such as *dominance hierarchies, territoriality, communication and mating systems.*
Students had to answer multiple choice questions (see appendix), had to do matching exercises (see appendix), a crossword puzzle (see appendix). They had the chance to see two English videos. The animal behaviour rally (see appendix), a kind of game/quiz, proved to be very successful. In human sociobiology we discussed the concepts of beauty and symmetry and the students had to measure the photos of faces of women and men. A lot of activities should help the students to understand the topic.

3.1.2. The visit of the headmaster

As I was allowed to choose an English lesson I liked, I decided for the first lesson of the ethology project. I was able to inform the students about the headmaster's visit one day before, so they were prepared (This means the students were on time, no forgotten books/folders, somebody sitting in the first row, ...). The students were very cooperative - only at the beginning a little shy and not so used to the English language in biology. Two very good students, however, rescued the situation at the beginning. Later on some others volunteered to answer some questions as well. Sometimes they only whispered correct anwers among themselves and I had to encourage them to repeat what they had just said. The headmaster was constantly writing an evaluation and closely observing my teaching and the participation of the class. He was interested in the lesson, liked the beginning, the mindmaps, the OHTs and my provocative questions to the problem whether behaviour is innate or learned, to get them speaking. He remarked the time lack at the end of the lesson when we couldn't complete the exercise on the different definitions of animal behaviour. He wanted to see far more student participation in the course of the project (a fact I partly disagree with) and I should pay attention that everybody speaks loudly enough. Although his attitude in this lesson was extremely nice and he was really interested in the project, I was not so happy when he asked whether he could come again some other time and so I tried to talk him out of it. Furthermore, he referred to my project in the conference and two colleagues voiced their wish to attend such a lesson and finally I was asked whether I could do a kind of poster about this project or a kind of film (only my class was enthusiastic about the latter suggestion) for the opening of the new building of the Landesschulrat of Lower Austria in May.

Valuable information about the lesson came from my students, who had known me from the other lessons. They told me that I had been much too fast at the beginning of the lesson, had used too many pictures and explained that that had been the real reason for not participating more at the beginning of the lesson. They also thought that there had not been too many new words and they mentioned that they had had plenty of possibilities of being active in the lesson. Obviously they realized and appreciated that the lessons had been much better prepared and there had been more activities than usual.

3.2. The rainforest project in 3E (see appendix)

The idea of doing a rainforest project in the third form evolved in the course of our English lessons when we were dealing with the story ‘ALONE AGAINST THE JUNGLE’. The students were writing chain stories on the topic ‘A PLANE CRASHED INTO THE JUNGLE’. Four students were working on one paragraph, then the paragraphs were passed on to the next group and so on till all of the students had contributed something to the final story. After teacher feedback (just underlining of mistakes - that’s why I don’t want to call it correction) the students had to find their mistakes. They worked in the same groups again and when they couldn’t find any more mistakes, they handed the stories to the next group. As the students were so proud of their essays and worked with apparent enjoyment, we decided to create posters and to put them up in the classroom. The students produced posters with their stories, crossword puzzles, and they decorated their posters with a lot of pictures of animals and plants living in the jungle. Although I appreciated their collaborative effort and their enthusiasm, the biology side in me made me wince at the sight of some animals, lions for instance. I felt I had to do something to guide them to a more accurate knowledge of the rainforest. So the rainforest project was the logical consequence.
In our next biology lesson we did a brainstorming exercise on creatures living in the jungle, wrote down on the blackboard the animals and plants the students already knew in English, introduced new words and did several activities (see appendix) to make them familiar with the new vocabulary, such as a mix and match exercise, the drawing of spidergrams and at the end of the lesson we developed a central idea graph. The next lesson we spent on the reading of different handouts and the students also had to read the book ‘Factfiles - Rainforest’ at home. In the third lesson we started with an animal game. A student described a jungle animal. Only yes / no answers were allowed. After my introducing the concept of food webs, the students were drawing their own food webs and were identifying the animals on the sheet ‘How many animals can you spot?’ Then the students got different handouts and produced posters to given topics. They worked together in groups of four on the following tasks: apes and monkeys in the rainforest, rainforest people, reptiles and amphibians in the rainforest, rainforest plants, the rainforest at night, wild cats, birds of the rainforest, and rainforest in danger. This stage of the project took about three lessons. The following tasks (see appendix) were meant to check the students’ understanding of the subject matter. They had to complete sentences, put together the beginnings and endings of sentences, correct some statements and had to answer questions. The final activity dealt with letter writing. Each group wrote a letter to two different organisations asking for information about the rainforests and finally we sent a letter to WWF International. My joy was great when the efforts of the students were rewarded before the summer holidays when they got a letter from WWF. All in all twelve rather interesting lessons!

4. The Questionnaire

With so much time and effort directed to lesson planning, it is important, therefore, to understand how worthwile it is. After completing both units I handed out a German questionnaire (see appendix) to all the participating students to learn about their opinions and see whether the attitudes of the students had changed during the course of the project.
18 students out of 20 completed the questionnaire in 6A (two girls were absent on that day) and 24 students out of 27 dealt with the same questionnaire in 3E (two pupils were absent, one had left our school). In the following chapter I just want to present the results mainly in the order suggested by the questionnaire. A more detailed discussion will follow in the next chapter.

4.1. Results - 6A

4.1.1. Students' likes and dislikes

The project was well-received by the pupils. A great majority was in favour of going on with the project, namely 13 out of 18, four had no preference. Only one objected to the continuation of the project. However, we won't have to take his wishes into account any more as he moved to Germany in the meantime.
8 students out of 18 liked the difference to "ordinary" lessons and the way the lessons were conducted best, one student mentioned that the whole project was a change and another student especially referred to the beginning of the project when everything was new. Four students chose the symmetry activity when we measured some photos, three thought the films were most interesting, two students opted for the extensive use of groupwork and one liked the quiz and the crossword puzzles best and commented that it was a nice way of checking the student's knowledge. Asked what they liked least, ten students chose not to answer this question and the remaining eight mentioned too much teacher talk / lectures on the topics, words too difficult, too many games, the animal rally (too many difficult words), studying of words, wordsearch, too many handouts and that a project of 15 lessons would not suffice to improve their English competence.

4.1.2. English / biology preference - students' participation versus English marks

11 students out of 18 preferred English to biology, two biology to English and five said that their preference depended on the topics studied. The marks of six students were 'Sehr gut' or 'Gut' and they all wanted to continue with English as the medium of instruction in biology. Of the remaining twelve students whose marks were 'Befriedigend' or 'Genügend', seven said that they would like to go on with the project, four did not show a preference and only one student did not want to carry on. 13 thought that their amount of participation was the same as in the German biology lessons, two said that their participation was not so good because the words were too difficult and three believed that their participation had improved as biology in English was more interesting for them, was something different and a new challenge.

4.1.3. Who should use English as a medium of instruction?

13 students out of 18 expressed their preference for two different teachers, a content teacher and another English teacher. Moreover, they commented that special knowledge of both, the

content teacher and the English teacher, was necessary. Thus they did not want to have a content teacher teach them in English if he/she was no English teacher. The fact that it should be two teachers was very important to most of them. They voiced their worries that their marks would be worse if the content teacher taught English in the same class. They feared for their biology marks as well as their English marks. The students were concerned that the content knowledge might be less important than the use of correct English and on the other hand were afraid that the 'bad impression' of their not so good performance might be taken over into the English class. Some students mentioned that certain students could be favoured because of their ability to express themselves in a better way than other students. Only 4 out of 18 would prefer the same teacher for English and biology. They argued that one could prepare the vocabulary in the English lessons and the work in the English lessons could support the biology instruction. One student believed that a teacher who taught English and biology in one class would know the strengths and weaknesses of the pupils and would therefore choose appropriate materials and teaching techniques.

4.1.4. Problems and profit

The questionnaire revealed the pupils' great wish for teacher correction of grammar mistakes although I hardly corrected them. Asked whether they wanted to have their mistakes corrected, they commented "Why not?" or "Of course. You can learn from mistakes!" 15 students out of 18 would like to have their grammar mistakes corrected in the future whereas only three objected to that practice mentioning that they might participate less in the lessons. In regard to vocabulary 11 students admitted they had problems, seven believed that the new words did not matter to them. Asked whether they thought they had profited from the project, eight pupils said that they had, especially for English but also for biology because they had to concentrate much more, nine remarked they had profited in the same way as usual and one was sure he had profited less because he was less interested and did not participate as much.
Although a lot of students were very pleased with the project and just wrote "Alles OK" when asked to write down their own suggestions for future projects, some students tried to think of some improvements. Most of their suggestions dealt with a more efficient approach to the amount of new words. One pupil suggested that listing the new words for the next lesson at the end of the previous lesson would be advantageous; another pupil voiced her wish to have specific terms translated into German; some pupils would have liked a biology vocabulary book. The grouping of students according to English competence was suggested. There should be at least one good English student in each group.

4.2. Results - 3E

4.2.1. Students' likes and dislikes

The responses to the question" Would you like to continue with the project?" revealed an overwhelming consensus bearing in mind the students' English marks. I was glad about the great acceptance of the project, 15 out of 24 wanted to go on with the new kind of biology instruction even though many of the students are really bad at English. Seven students said they did not mind English as a medium of instruction and would be happy with English or German, only two boys were dissatisfied with the new way of instruction. Surprisingly, both boys did not have bad marks. Asked what they liked best, 23 out of 24 liked doing the jungle posters best, only one pupil remarked that the best thing of the project was that mistakes did not count. 21 students did not mention anything negative, only three wrote down too little time and animal games.

4.2.2. English / biology preference - students' participation versus English marks

10 out of 24 pupils preferred English to biology, six said that they liked both subjects in the same way and eight stated that they preferred biology to English. One student out of this group rejected the continuation of the project whereas six mentioned that they would be glad about further biology instruction in English.
Their English marks did not seem to have influenced their decision for wanting to continue with the project or stop the project. Out of the four students who had marks 'Sehr gut' or 'Gut', two were in favour of the project and two did not mind. 18 students had marks 'Befriedigend' or 'Genügend'. Two students did not fill in their marks, but obviously should have been in the second group. 10 out of 18 were happy with the project and wanted to go on with it, four did not voice any preference and two objected to the English instruction.
Asked how they assessed their participation, ten students claimed that their participation had improved because the lessons were more interesting. Other reasons given were because it is a challenge, it is more exciting, it is something new, because it is not marked. One student believed as she was good at English, her participation in biology would automatically be better. Ten thought they participated in the same way as in the other biology lessons, three said they would participate less. One of these three, however, explicitly stated that he / she was in favour of the project and wanted to go on after all.

4.2.3. Who should use English as a medium of instruction?

The answers to this question were in sharp contrast to the ones of 6A. 19 out of 24 preferred one teacher (as it was the case in our class) to two different teachers. They argued they had got used to the teacher, had more confidence as they knew the teacher better. They also pointed out the possibility of continuing with some tasks of the project in the English lessons. Only two students expressed their preference for two different teachers. They were afraid their English marks could be negatively affected. Two other students would have preferred a content teacher (no English teacher) as they assumed that no mistakes would be corrected and the English teachers would be stricter according to their opinion.

4.2.4. Problems and profit

The wish for teacher correction was again striking. 20 students would have preferred correction compared to four students who were satisfied with the way it was. To my great surprise, 20 out of 24 claimed they did not have problems with the new words because of the translations, only four admitted to have encountered some difficulties.
Nine students believed they had profited more for biology, eleven thought they had profited in the same way, only one student stated to have got less out of the English instruction. Five students explicitly mentioned they had the impression of having improved in English. One student chose not to answer this question.
The suggestions made by the students of 3E were rather similar to the ones in 6A like watching more films, doing more posters, more competitive games like ”Vokabelkönig”. There was also some praise like ”Perfect lessons!” or one student wanted to have English instruction in biology for the rest of the year.

5. Discussion

The primary purpose of this questionnaire was to find out about the students' attitudes towards English instruction in biology and the results should serve as a guide for my future teaching. The following discussion will mainly be limited to pointing out the most striking differences between the answers in the two classes or between the results and my expectations. The acceptance of the project was rather striking in 6A. 72 per cent (13 students) wanted to continue with the project, 62 per cent in 3E (15 students) compared to only 5 per cent dissatisfied pupils (1 student) in 6A, and 8 per cent (2 students) in 3E. When I discussed the results of the questionnaire with the respective classes, it was interesting for me that all students who rejected the project were boys and to my surprise they were not bad at English. All of them had 'Befriedigend' in their reports and just seemed not willing (too lazy?) to work more than necessary. The boy in 6A and one of the boys in 3E were really good at biology and also might have resented that some of the other students now participated more and so they might have worried about their good impression on the teacher. When we did a final project 'ecology' on a rather voluntary basis in 6A at the end of the school year, some girls wanted him to join their English instruction group (there were German ones as well). Although he was easily persuaded to join them, he did not really work in a constructive way, on the contrary he teased the German group "Deutschunterricht ist für Stümper." After all, his attitude won't be of any concern to me any more as he moved to Germany at the end of the year. On the whole the girls in both classes seemed to be more enthusiastic than the boys.
At this point it seems worthwile considering the students' marks in English , their preference for English or biology and their attitudes towards the project. In 6A 61 per cent (11 students) preferred English to biology and 11 per cent (2 students) biology to English. (The others could not decide for one and said that it depended on the topic.) The result of this class was not surprising for me because first of all, 6A is a language-orientated class and all biology teachers are aware that their students are very interested in biology in forms 1 to 4 when animals, plants and human anatomy are discussed but quickly lose interest from the 5th form on when there is a lot to study, the lessons become more factual and less relevant to their everyday life. One of the two students who preferred biology to English is an excellent student in all subjects, extremely interested in biology and was very much in favour of English as a medium of instruction.
On the other hand, the results of 3E I had not expected at all. I simply could not imagine that 41 per cent (10 students) of this class actually preferred English lessons to biology lessons opposed to 33 per cent (8 students) who favoured biology - especially when I was thinking of all the students having to work really hard just to pass the year (some only scraped through the year) and the work I had to do which was considerably more than for any form 5 to 8 I taught at that time. Obviously, I asked the class to give me some reasons for their choice as I had not indicated that on the questionnaire. Their answers made it apparent that my own attitude to both subjects seemed to have a bearing on their preference for English. Moreover, I had to admit that I was prepared to do much more work for English than for biology. Whenever I was short of time, it was the biology classes that "suffered" from it, on the other hand I was always willing to do a lot of extra work for my English classes (even voluntary lessons after class before tests, extra corrections of their individual writings or in depth lesson planning).
It seemed to me that my own attitude was perhaps as crucial as their own marks. One girl in my third form who just achieved a 'Genügend' in English and excelled in biology commented

that she preferred English to biology because it was more fun. When I asked the students whether their English knowledge was very good (marks Sehr gut or Gut) or good (marks Befriedigend or Genügend), I wanted to find out whether there is a correlation between the level of proficiency in English and the acceptance / rejection of the project. The students in 6A, however, resented that question very much and pointed out that knowledge and marks do not necessarily correspond. A fact I am well aware of. I should have used a different wording. The results of the questionnaire suggested that English marks seemed to be important in some cases for their accepting or rejecting the project. In 6A all those who had marks 'Sehr gut' or 'Gut' wanted to continue with the project and for them English in biology made biology more interesting. Some believed that their participation had improved by the use of English and in some cases this was exactly what I had observed. Even in 3E 10 students out of 24 believed that their participation had improved as they liked the lessons better. From my own observations I was not able to see a marked difference in participation as 3E was a lively, active class anyway but their enthusiasm was promising.
Another striking difference between the two classes was their preference for just one or two teachers respectively. In 3E 19 students out of 24 were in favour of just one teacher and only two would have liked two teachers. It was the other way round in 6A, 13 out of 18 preferred two teachers and only four would have favoured one. This result was rather unexpected and I have difficulties trying to find an explanation. By chance both classes got what they preferred, 6A had a different English teacher and 3E had to put up with my teaching. Perhaps the students favoured the routine they had got used to over the year. Another explanation might be that the students of 6A having been at school three years longer had perhaps become more critical and aware of certain perceived cases of "injustice". In addition, in my two classes a general prejudice seemed to prevail against teachers teaching content through English when they are no English teachers as well - only two students in 3E would have liked that. One comment in 6A was rather intolerant "Stümperhaft Vorgetragenes, so leid es mir tut, verdient nur Verachtung!" This attitude seems to stem from the students' ideal image of a teacher who has to know simply everything. However, at our school there is a science teacher who tried out a few lessons in English and her fifth form was happy with her teaching and said that they preferred her to an English teacher, as they were convinced that an English teacher would be stricter. (Again another prejudice!)
What remains to be done is to clarify my own role as an English and content teacher. At the beginning of my teaching biology in English I had great difficulties to define my tasks. The only thing I knew was that I liked it much better than teaching biology in German as it was a great challenge. But when my students used for example questions wrongly (dropped the 'do' or 'does'), or used incorrect irregular verbs, I was not happy at all and corrected quite a lot. On the other hand, I was very proud of their vast knowledge of new words. When some other students did not join a skiing course and attended my third form, I was extremely satisfied when we played an animal game in the course of a unit "pets and pests" and my students mastered words like "cockroach, tick, shell" without problems and our guests soon asked just to listen. On second thoughts, however, I doubt whether an accumulation of new words can be counted as an improvement in language competence. Generally, I correct very little in forms 5 to 8 and I correct "bad mistakes" in the other forms, especially when I feel responsible being their English teacher. Usually students just watch my face and easily can see whether something was wrong. In the meantime I have come to correct fewer grammar mistakes in oral activities due to the reading of special literature, however, my practice does not correspond with the students' overwhelming wish for teacher correction. Students and some teachers seem to take it for granted that the students do learn from teacher correction. The students' wish for error correction is opposed to the view of some researchers such as Hillocks and Leki, who think that total correction may hinder language learning, and may

influence students' attitudes in a negative way. A language teacher should provide for both error correction, a form of negative feedback, and positive sanctions or approval of learners' production. But what about a content teacher teaching in a foreign language? There are so many questions that the issue of correction / feedback lies far beyond the scope of this paper. Questions like "Should learner errors be corrected? Which errors should be corrected?" would deserve a separate treatment. As my students ask for teacher correction, I might consider the matter and just repeat their sentences in another way.

What I have also learned from the questionnaire is to pay much more attention to the translation of specific terms. Obviously my attempt to give definitions for these terms in 6A rather than translations did not meet the needs of my learners, who reported to have problems with the specific vocabulary, compared to the students of my third form, who were happy with the translations. It seemed to me that the better, the more conscientious students in 6A were more worried about not understanding certain words than not so good or younger students.

On the whole the results of the questionnaire have helped me to learn about the attitudes of the students. I am aware, however, that certain limitations are placed on the generalizability of results achieved in this study, due to the variables such as different age, different proficiency in English, different interests (language-orientated versus economics-orientated), motivation, and the differences in personality. Thus the results won't be completely applicable to other classes but the students' answers have helped me to gain some insight and will serve as a guide for my decisions in lesson planning.

6. Conclusions for the future: Great Expectations – Hard Times

I am convinced that I will definitely go on with English as a medium of instruction in my biology lessons. What's more, due to the enthusiasm of my students experiencing the accurately planned lessons with a lot of games and activities, I have reluctantly started to change my biology lessons as such. We've produced games, quizzes, posters so far. Personally, I am rather pleased with the outcome of the project. Nevertheless, there are certain problems, rather challenges (one should think in a positive way!) for my teaching which worry me a lot, such as the "most effective" way to mark the students' participation versus non-participation (I haven't so far) and the great amount of time needed for the preparation of the materials (e.g. 400 quiz cards for one game!), the ideal grouping and the nature of instruction.

As learning is a collaborative process, it is important for me to meet my students' needs to enable them to fulfil their task to make sense of instructional tasks posed, attaining a sociolinguistic competence to allow greater participation, and finally learning the content itself. The future will prove whether the great expectations will be fulfilled. Definitely the evaluation of the project is still far away. But I have succeeded in some small respects - students don't fear for their good marks so much any more, on the contrary, some have improved their marks by giving talks in English, for example, though no one has actually been forced to do so. I am definitely glad and proud that the relationship between the classes and myself is working extremely well and even some (critical) parents find positive comments about the project. So I'm encouraged to go on agreeing with Britton who reminds

us that ”every lesson should be for the teacher, an inquiry, some further discovery, a quiet form of research.”
Teaching is also said to be a journey. So let’s prepare for it! Bon voyage!
At last let’s take Zora Neale Hurston’s (a parent’s) advice for teachers ”Jump at the sun. You might not land on the sun, but at least you’ll get off the ground.”
Obviously great expectations ahead - and hopefully not too hard times!

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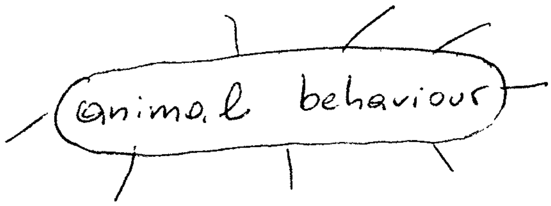
APPENDIX A

6A

LESSON PLAN

1) INTRODUCTION
   - words
   - books

2) MINDMAP



OHT 1
OHT 2

3) OHT : NEST- BIRDS
   - Identify the chick's behaviour: beaks wide open, necks extended, chirping
   - Behaviour of the mother bird: dropping food, learning to get more food
   - Behaviour learned? or innate? Why do they behave as they do? Present a problem: What if the mother bird has three chicks, but only enough food to feed two? What might the chicks do to solve the problem? What might the parent bird do? → siblicide as a means of decreasing competition of resources. (siblicide ↔ altruism)

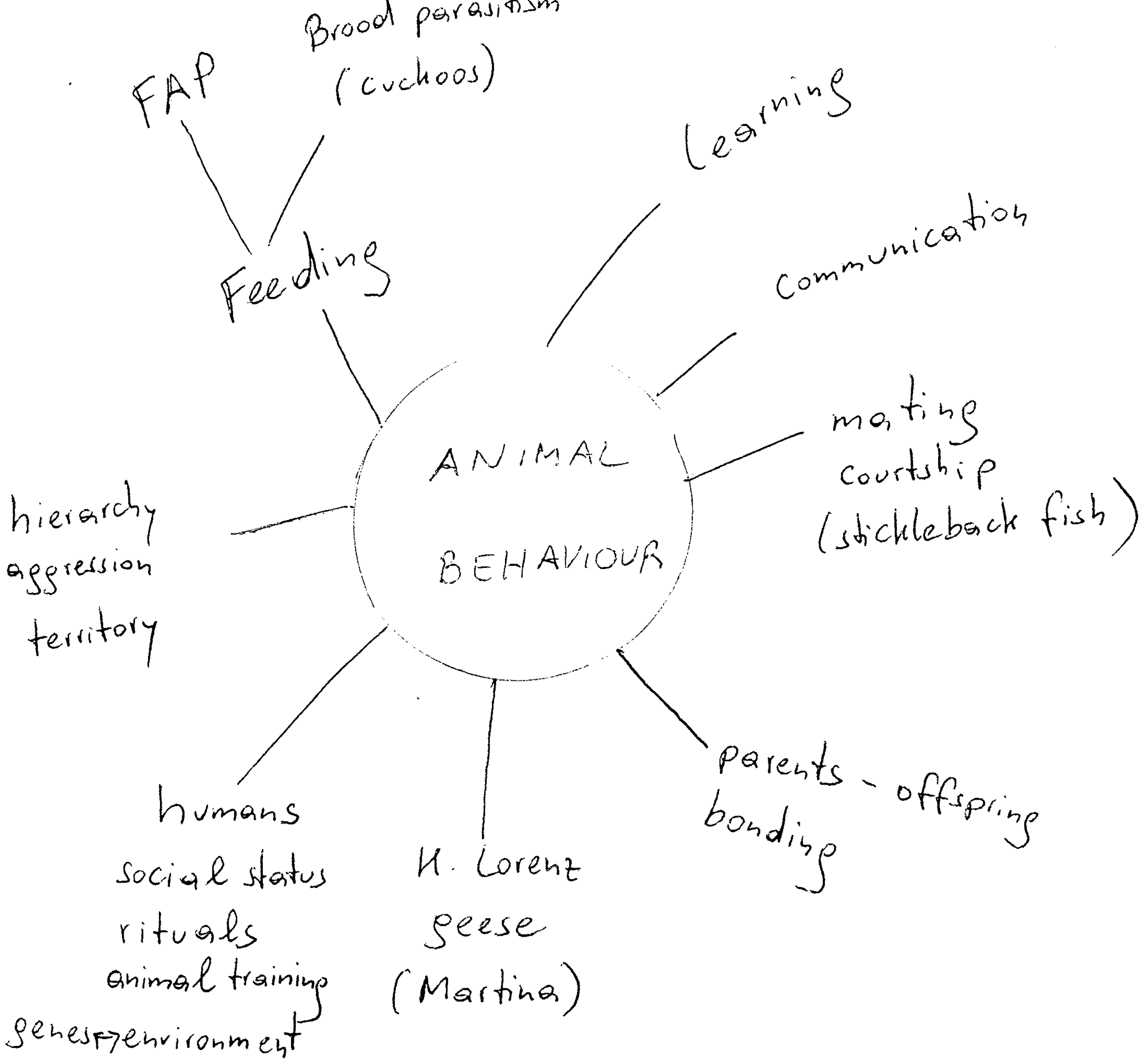
4) OHT 3 learned behaviour – innate behaviour

5) "ENVELOPE- GAME"
   - what is animal behaviour?
   - order cards
     - true
     - false
     - don't know/understand
   - "best" definition

6) LECTURE

7) MATCHING EXERCISE

OHT 1


ANIMAL BEHAVIOUR
Feeding
FAP
Brood parasitism (cuckoos)
Learning
Communication
mating
courtship
(stickleback fish)
parents - offspring
bonding
K. Lorenz
geese
(Martina)
humans
social status
rituals
animal training
genes/environment
hierarchy
aggression
territory

OHT 2

Environment

Kinesis + Taxis

Migration Behaviour
- piloting
- orientation
- navigation

Foraging
(intake of food)

Sociobiology

agonistic b. ↔ altruistic b.

dominance hierarchy

territoriality – aggression

communication

courtship – (sexual selection)

mating systems
- promiscuous
- monogamous
- polygamous — polygynous / polyandrous

SURVIVAL OF THE FAMILY / INDIVIDUAL /

ANIMAL BEHAVIOUR

SURVIVAL OF THE FITTEST
(DARWIN)

Innate

FAPs
(Fixed-Action Patterns)

Learning

learning versus maturation
(birds – flying)

habituation

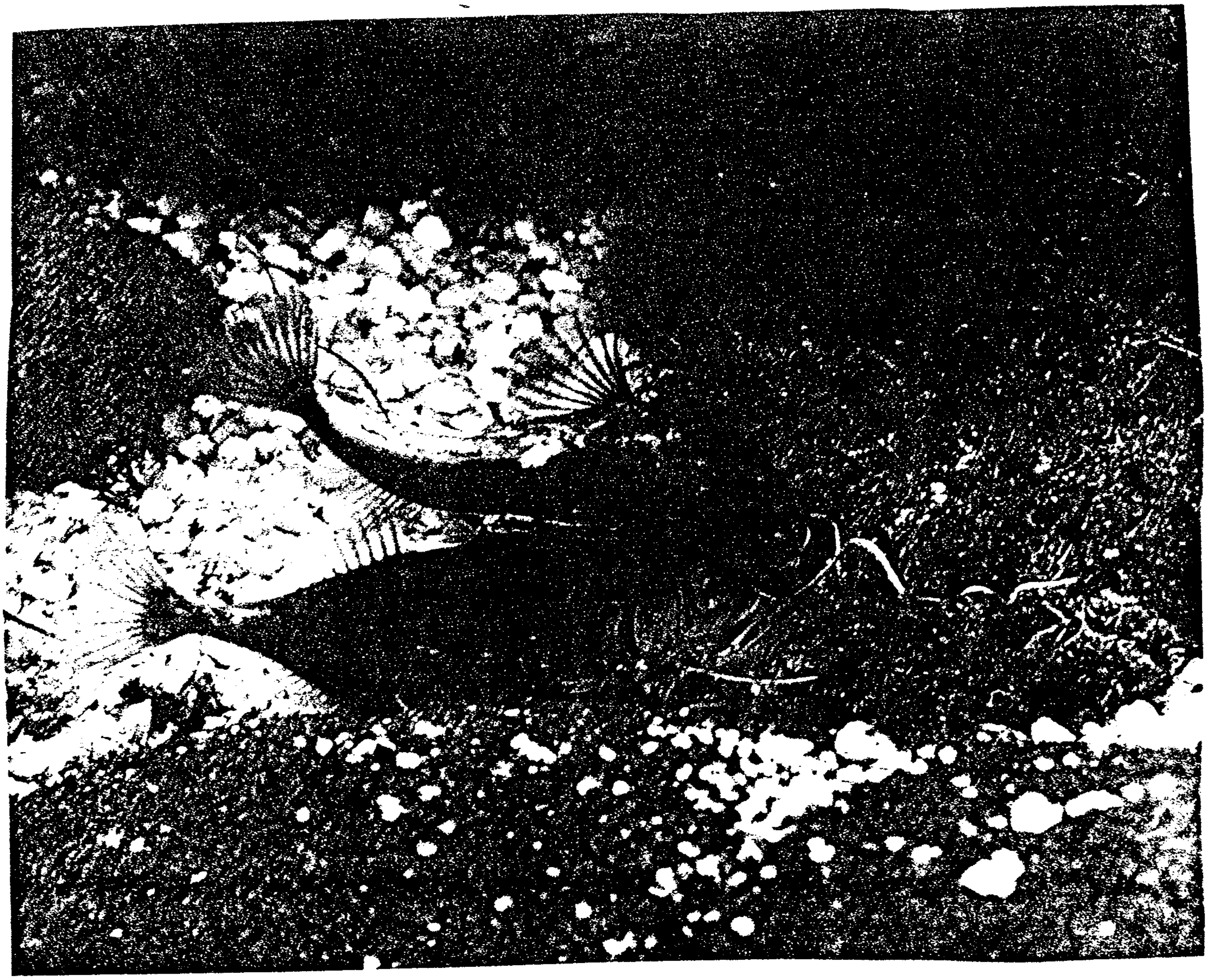
imprinting – Lorenz – geese

classical conditioning
(Pavlov)

operant conditioning
(Skinner)

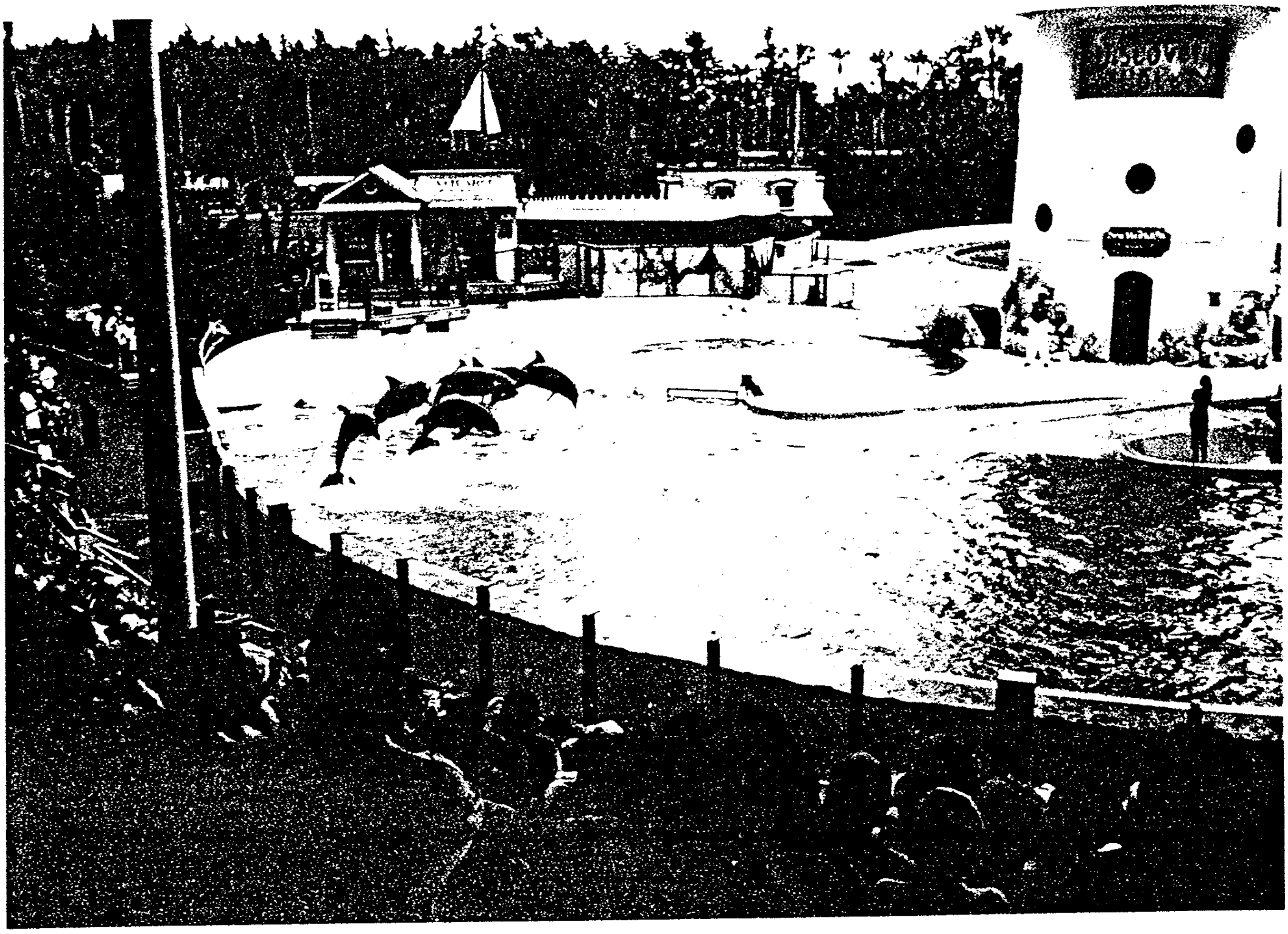
observational learning

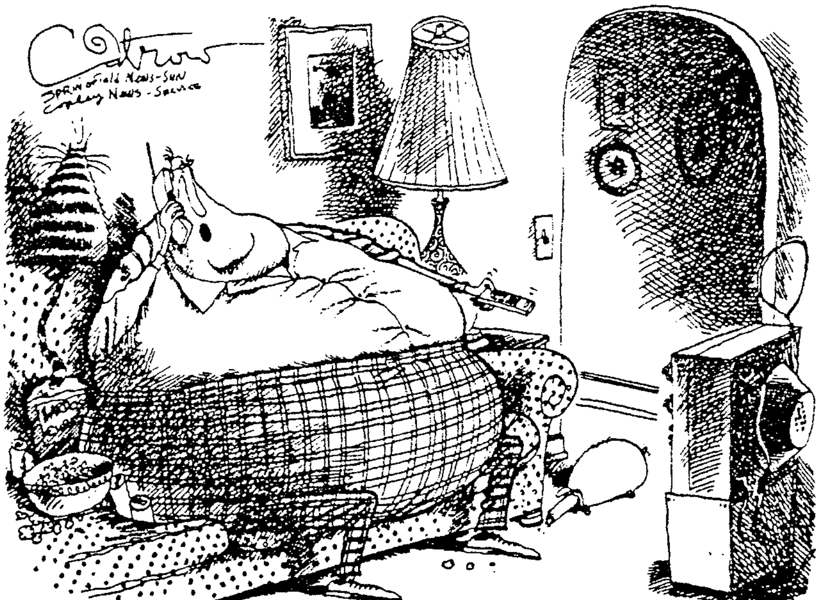
OVERHEAD TRANSPARENCIES



Paviane im Bild

Fotos: Prof. Dr. Walter Götz, Ammerswil, Schweiz





"IT'S CRUEL - MY ADVENTURE GENE'S BEEN BEATEN INTO SUBMISSION BY MY DOMINANT BIG BUTT GENE."

Genes are being used as an excuse for bad behaviour

Don't blame us

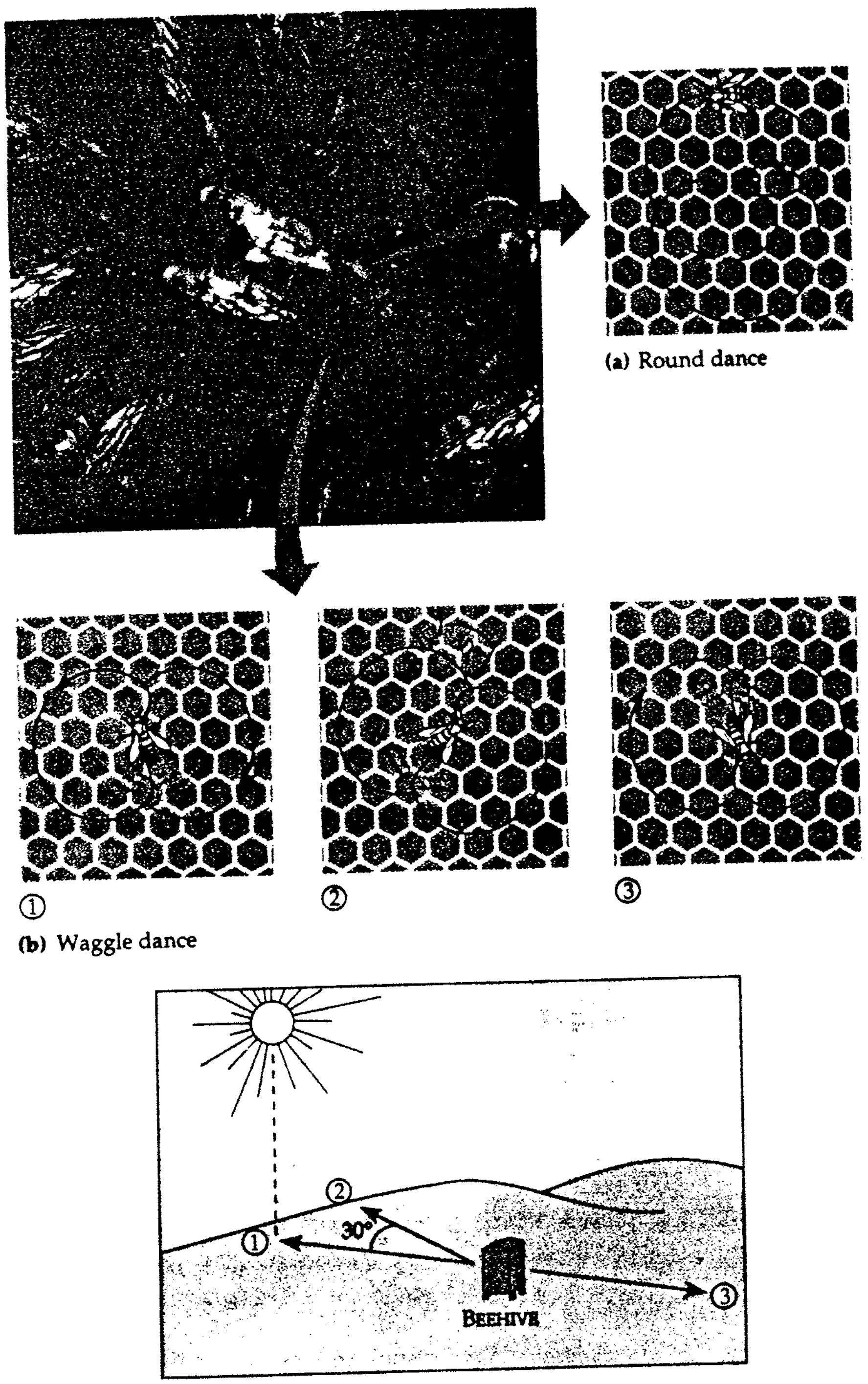
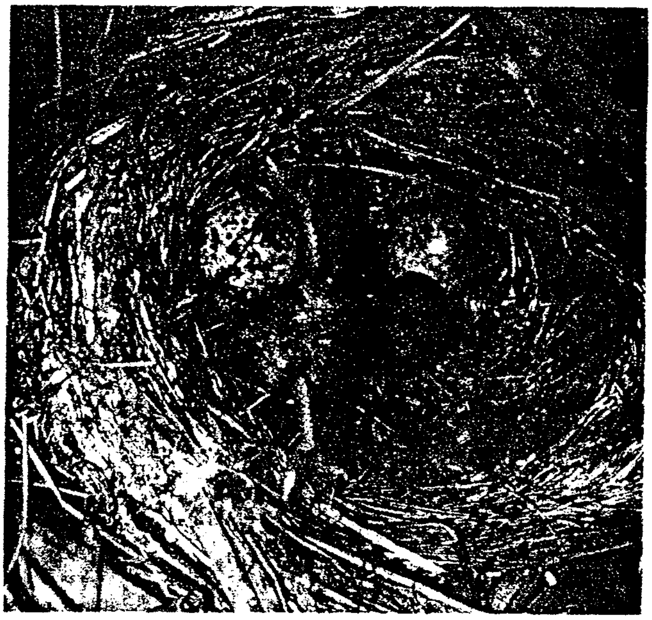


FIGURE 50.22
Communication in bees: one hypothesis. **(a)** The [redacted] indicates that food is near but provides no information on directionality or specific distance. **(b)** The [redacted] performed when food is distant. This dance pattern resembles a figure eight, with a straight run between two semicircular movements. According to von Frisch's hypothesis, the waggle dance indicates both distance and direction. Distance is indicated by the duration of each waggle run or dance and the number of abdominal waggles performed per waggle run. Direction is indicated by the angle (in relation to the vertical surface of the hive) of the straight run that forms part of the dance itself. ① For instance, if the straight run is directly upward, this signals that food is in the same direction as the sun. ② If the angle is 30° to the right of vertical, the food is 30° to the right of the sun. ③ If the straight run is directly downward, the food is in the direction opposite the sun. Odor cues and sound may also convey information about the location and type of food

convey to one another the location of good food sources, which may change frequently as various flowers bloom or new patches are discovered. [redacted] The study of honeybee communication has a long and rich tradition of experimental research that continues to reveal new elements of the bees' language. The problem was first studied in the [redacted]who carefully watched individual European honeybees (*Apis mellifera carnica*) as they returned to special observation hives. The returning bee would quickly become the center of attention by other bees, called followers, [redacted] to go through a repetitive behavior that von Frisch called [redacted] (FIGURE 50.22). If the food source was close to the hive (less than 50 m away), the returning bee moved in [redacted]s while waggling its abdomen from side to side. This dance was usually accompanied by the bee's regurgitating some of the acquired nectar. This behavior, which von Frisch called the [redacted], had the effect of exciting the follower bees and motivating them to leave the hive and search for f[redacted]



(a)

(b)

FIGURE 50.7

Brood parasitism. Some species of European cuckoos are brood parasites, meaning that they lay their eggs in the nests of other species. (**a**) Within hours of hatching, an otherwise helpless cuckoo methodically pushes all of the host's eggs out the nest. If the cuckoo hatches after some or all of the nestlings have already hatched, it will evict them as well. There is no opportunity for cuckoo nestlings to learn this behavior from another individual, so it must be innately programmed. (**b**) The host, in this case a reed warbler (left), feeds the brood parasite even though the baby cuckoo looks nothing like a much smaller nestling warbler. The gaping mouth of a nestling, whether true offspring or brood parasite, is the releaser that causes the parent (or foster parent) to feed the baby. Even in those species where some kin discrimination is possible, the gaping mouth of the cuckoo is much larger and more aggressive than that of the host species and thus serves as a supernormal stimulus. Although they do not differentiate among nestlings, reed warblers and many other birds recognize their own eggs and remove cuckoo eggs that are dissimilar. This has resulted in the evolution of cuckoo eggs that are nearly identical to those of many host species.

ground (see FIGURE 50.4) and places in it a paralyzed cricket she has just stung. She then lays an egg that will eventually hatch into a larva that consumes the cricket. The wasp accomplishes all this with a highly stereotypical series of FAPs. She places the cricket a short but rather precise distance (about 2.5 cm) from the nest, enters the nest briefly, apparently for a final inspection, then comes out to get the cricket and carry it into the nest. If an observer moves the cricket a short distance while the wasp is inside, she searches for it after emerging and, after retrieving it, puts it back in its original spot near the entrance. She then enters the nest for another inspection, even though she has just made one, and emerges again a short time later. If the cricket has been moved again, the wasp repeats the cycle—and will continue to repeat it at least forty times, showing no sign of either tiring of the repetition or of circumventing the scientist's game by changing behavior. The wasp can only get past the "inspect-the-nest" step by immediately finding the cricket near the nest. In nature, such behavior may be quite adaptive. Movement indicates that the cricket is not truly paralyzed, and the wasp would have to sting the cricket again and eventually subdue it. A reinspection of the nest by the wasp after a long time spent struggling with the cricket would also be prudent and useful.

The Nature of Sign Stimuli

Ethologists have found from experiments that sign stimuli for FAPs are generally based on one or two simple characteristics. In many cases, the stimulus is the most obvious (or the only) characteristic of a particular situation; for example, the ultrasonic signals of bats are the obvious cue for triggering avoidance behavior in moths. In other cases, it appears that animals have settled on certain characteristics out of an array of possible choices. When an adult herring gull brings food to its chick, it bends its head down and moves its beak, which has a red spot. The chick pecks the beak, stimulating the adult to regurgitate the food. The chick might be cued to peck by a variety of stimuli, including such obvious things as a lump at the end of a rectangle (simulating food at the end of a bill). However, studies have demonstrated that the releaser is a red spot swung horizontally at the end of a long, vertically oriented object. We expect natural selection to have favored cues having a high probability of association with the relevant object or activity, but when there are many possible cues, there is probably some randomness in which one becomes fixed upon as the sign stimulus for a FAP.

Close correlations exist between an animal's sensitivity to general stimuli and the specific sign stimuli to which it responds. For example, frogs have retinal cells that are especially good at detecting movement, and it is the

OHT 3

ANIMAL BEHAVIOUR

SURVIVAL OF THE INDIVIDUAL / FAMILY

Learned behaviour - - - **Innate behaviour**

Learned behaviour
- acquired after birth
- learned from others
- animals that have long life spans, complex nervous systems
- mammals

Innate behaviour
- genetically passed on from parent to offspring
- insects

Siblicide: rare behaviour. Most often observed in predatory birds.

Altruistic behaviour: behaviour is geared towards the common good rather than the survival of the individual.

(worker honeybees, ants, termites)

"ENVELOPE - GAME"

(15 DIFFERENT DEFINITIONS OF ANIMAL BEHAVIOUR)

Behaviour is what an animal does and how it does it.

Behaviour is a complicated interaction of genetics and environmental factors.

Ethology, the study of how animals behave in their natural environment, originated in the 1930s.

Learning is experience-based modification of behaviour.

Human language and bird songs are examples of learned behavioural variations of an innate ability.

Insight learning, sometimes called reasoning, involves the ability to perform correctly in a novel situation.

Insight learning is most observed in mammals, especially in primates, although such learning has been documented in some beetle species.

Behaviours result from interactions among environmental stimuli, experience, and individual genetic makeup.

The study of behaviour integrates biochemistry, genetics, physiology, evolutionary theory and ecology.

Behaviours can range from simple fixed-action patterns in response to specific stimuli to insight learning in novel situations.

The parameters of behaviour are controlled by genetics and thus are acted upon by natural selection.

Human behaviour represents an integration of genes and culture.

A change in behaviour as a result of experience is called maturation.

Genes control all we do.

Behaviour results from the interaction of sense organs, nervous systems, muscles, and other parts of the animal's body.

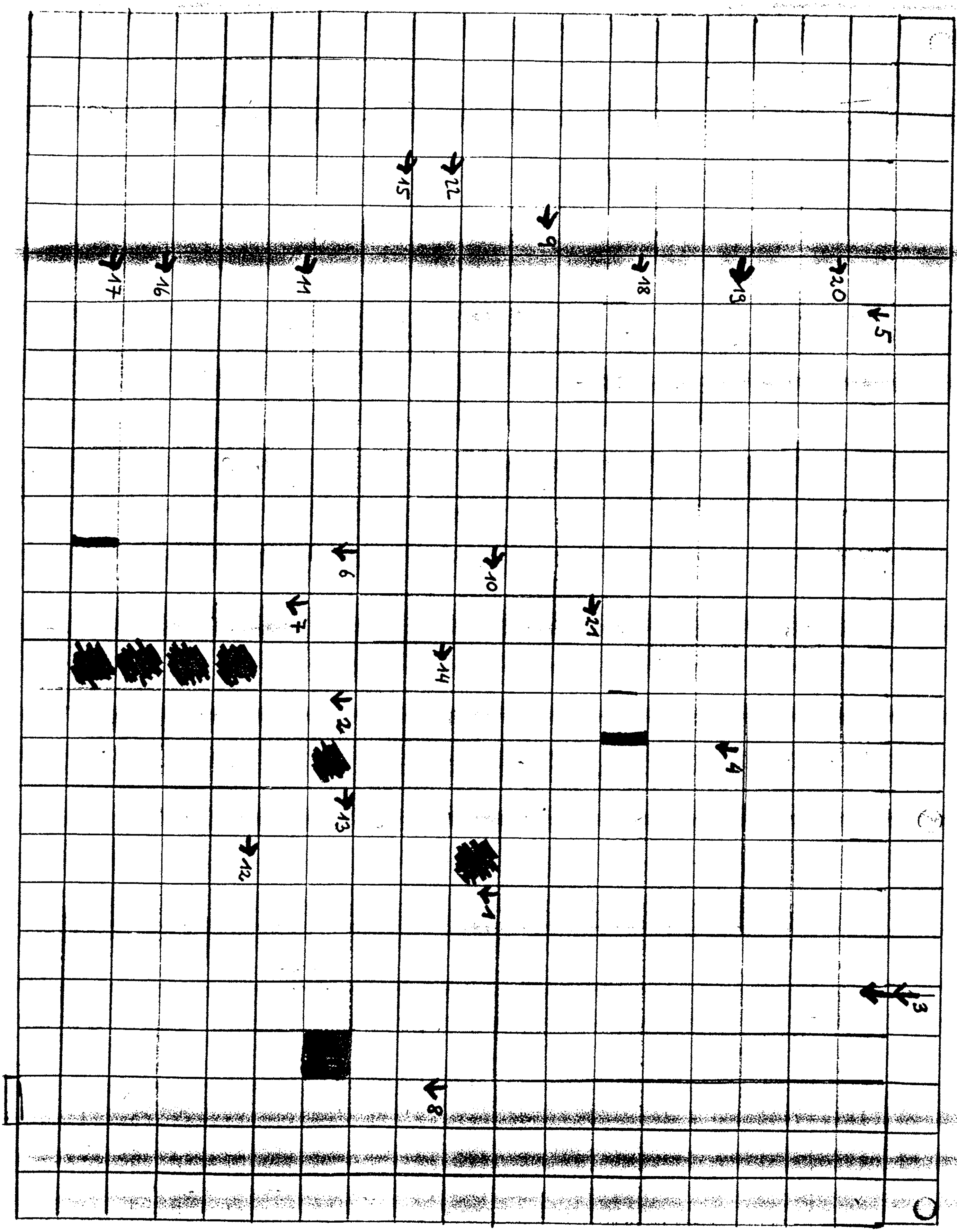
CROSSWORD PUZZLE

Down

1) the study of how animals behave in their natural environment
2) a famous Austrian ethologist – associated with imprinting
3) a scientist famous for his experiments with salivating dogs
4) the modification of behaviour as a result of experience
5) a highly stereotyped, innate behaviour, triggered by a sign stimulus
6) the name of the most famous graylag goose Konrad Lorenz worked with
7) the automatic response to a stimulus moving either toward or away from the stimulus
8) mother-offspring bonding is an example

Across

9) animals used in operant conditioning
10) a scientist associated with natural selection (survival of the fittest)
11) the loss of sensitivity to unimportant stimuli
12) **Pavlov worked with these animals**
13) the animals Konrad Lorenz worked with (singular!)
14) Pavlov and Skinner are famous for their research in this field
15) a scientist associated with operant conditioning
16) von Frisch worked with these animals
17) a famous Austrian ethologist who described communication among bees
18) a process that describes the changes in neuromuscular systems due to developmental changes (birds "learning" to fly)
19) looks to evolution for explanations of animal behaviour
20) a change in activity rate in response to a stimulus
21) an area established for feeding, mating, and/or rearing young
22) travelling from a familiar landmark to another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ANIMAL BEHAVIOUR - RALLY

Draw a card.

When you know the answer you can take the short cut next time.

RULES OF PLAY

2 to 4 players

1) The cards are placed with the questions upwards.

2) Players roll the die, with the player rolling the highest number moving first. The player with first turn rolls the die again and moves the token the indicated number of spaces. Players decide whether any number of tokens may occupy the same space or only the first one.

3) When a token lands on a fish, the player draws a card and answers the question. (Answers are on the opposite side of each card.) If the player correctly answers the question, he can move 3 spaces forwards. If the player answers incorrectly, he has to move 5 spaces backwards.

4) When a player lands on  he has to answer the question of the <u>first</u> card. If the player answers correctly, he may take a short cut.

5) The player wins who comes to the finish first. To finish the game players must land in the finish headquaters.

QUIZ CARDS for ANIMAL BEHAVIOUR-RALLY

FIXED-ACTION PATTERN (FAP)

is a highly stereotyped, innate behaviour that, once begun, is usually carried through to completion. It is triggered by a sign stimulus or releaser.

ETHOLOGY

the study of how animals behave in their natural environment.

BEHAVIOURAL ECOLOGY

looks to evolution for explanations of animal behaviour, with the underlying expectation that animals behave in ways that maximize their Darwinian fitness.

LEARNING

is the modification of behaviour as a result of experience and can affect even innate behaviours.

HABITUATION

is the loss of sensitivity to unimportant stimuli or to stimuli not associated with appropriate feedback.

IMPRINTING

Learning has a specific innate component. Mother-offspring bonding is critical for survival of offspring and for the reproductive fitness of the parent. The imprinting stimulus for newly hatched geese is the movement of an object, whether it be their mother, or Konrad Lorenz.

CLASSICAL CONDITIONING

described through the work of Pavlov in the 1900s with salivating dogs, illustrates the association of an irrelevant stimulus with a fixed physiological response.

OPERANT CONDITIONING

refers to trial-and-error learning through which an animal associates a behaviour with a reward or punishment. (Skinner)

KINESIS

is a change in activity rate in response to a stimulus.

TAXIS

is the response to a stimulus by automatically moving either toward or away from the stimulus.

MIGRATIONS

are long-distance, regular movements, often involving a round trip each year. (birds)

Travelling from one faniliar land-mark to another is called

PILOTING

ORIENTATION

occurs when an animal detects compass directions and moves in a straight line.

NAVIGATION

involves the ability to detect compass direction and to determine present location relative to destination (a "map sense").

SOCIAL BEHAVIOUR

involves interaction between two or more animals, usually of the same species. The discipline uses evolutionary theory as the basis for studies of social behaviour.

AGONISTIC BEHAVIOUR

involves a contest to determine which competitor gains access to a resource, such as food or a mate.

DOMINANCE HIERARCHIES,

as illustrated by the "pecking order" of hens, prevent continual combat by establishing which animals get first access to resources.

TERRITORY

is an area established for feeding, mating, and/or rearing young from which conspecifics are excluded.

COURTSHIP INTERACTIONS

unique to each species, assure that individuals are not a threat and that they are of the proper species, sex, and physiological mating condition. These complex rituals often consist of a series of fixed-action patterns.

PROMISCUOUS

no strong pair bonds

MONOGAMOUS

strong pair bond - 1 partner

POLYGAMOUS

strong bonds- more than 2 partners

POLYGYNOUS

one male and many females

POLYANDROUS

one female and many males

COMMUNICATION

is the intentional transmission of information between individuals using special behaviours called displays.

SOCIOBIOLOGY

applies evolutionary explanations to human social behaviours.

ALTRUISM

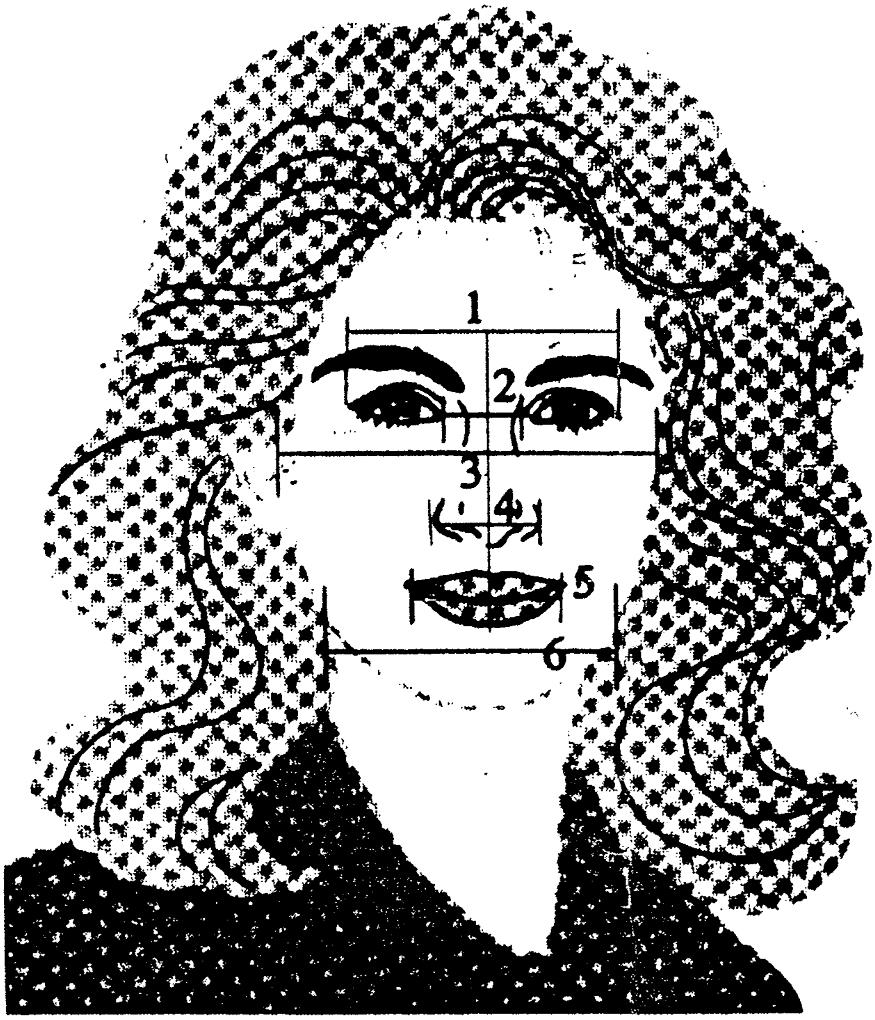
is behaviour that reduces an individual's fitness while increasing the fitness of the recipient.

CRITICAL PERIOD

is a limited time during which imprinting can occur.

ANIMAL BEHAVIOUR
MATCHING EXERCISE

1 ETHOLOGY	is the modification of behaviour as a result of experience and can affect even innate behaviours.
2 FIXED-ACTION PATTERN (FAP)	the study of how animals behave in their natural environment.
3 LEARNING	looks to evolution for explanations of animal behaviour, with the underlying expectation that animals behave in ways that maximize their Darwinian fitness.
4 HABITUATION	refers to trial-and-error learning through which an animal associates a behaviour with a reward or punishment. (Skinner)
5 CLASSICAL CONDITIONING	is the loss of sensitivity to unimportant stimuli or to stimuli not associated with appropriate feedback.
6 IMPRINTING	Learning has a specific innate component. Mother-offspring bonding is critical for survival of offspring and for the reproductive fitness of the parent. The imprinting stimulus for newly hatched geese is the movement of an object, whether it be their mother, or Konrad Lorenz.
7 BEHAVIOURAL ECOLOGY	described through the work of Pavlov in the 1900s with salivating dogs, illustrates the association of an irrelevant stimulus with a fixed physiological response.
8 OPERANT CONDITIONING	is a highly stereotyped, innate behaviour that, once begun, is usually carried through to completion. It is triggered by a sign stimulus or releaser.



FACES

1) Measure the six different distances as shown in the picture.
2) Find the median line.
3) Find the distances from the six central points to the median line.
4) Add these distances.
5) Then divide the sum through measure 3.
   The result is the <u>symmetry index</u>.
   The more symmetrical the face is the smaller is the numerical value. In the ideal case it would be 0 (all central points are on one line).

HANDOUT (Interactive questions, multiple choice)
STUDENT STUDY GUIDE for Campbell's BIOLOGY
(Martha R. Taylor - Cornell University)

CHAPTER 50

BEHAVIOR

FRAMEWORK

This chapter introduces the complex and fascinating subject of animal behavior. The study of behavior integrates biochemistry, genetics, physiology, evolutionary theory, and ecology.

Behaviors can range from simple fixed-action patterns in response to specific stimuli to insight learning in novel situations. Behaviors result from interactions among environmental stimuli, experience, and individual genetic makeup. The parameters of behavior are controlled by genetics and thus are acted upon by natural selection. Behavioral ecology focuses on the ultimate cause of reproductive fitness, which can be used to interpret foraging behavior, agonistic interactions, mating patterns, and altruistic behavior. Sociobiology extends evolutionary interpretations to human social interactions.

CHAPTER REVIEW

■ Behavior is what an animal does and how it does it

Animal **behaviors** are observable movements or actions as well as unobservable physiological or neural changes in response to a stimulus.

■ Behavioral ecology emphasizes evolutionary hypotheses: *science as a process*

Behavioral ecology looks to evolution for explanations of animal behavior, with the underlying expectation that animals behave in ways that maximize their Darwinian fitness. This expectation of optimal behavior relies on the fact that behavior is influenced by genetics and therefore subject to natural selection. Behavioral ecology allows researchers to frame questions about animal behavior in an evolutionary context, develop hypotheses, and make testable predictions.

■ A behavior has both an ultimate and a proximate cause

The **ultimate causation** of a particular animal behavior relates to the evolutionary basis of the behavior—why it has been favored by natural selection. **Proximate causation** explains the immediate cause of a behavior in terms of the cues or stimuli that trigger it and the internal mechanisms that produce it. Animal behaviorists must consider what they call *umvelt*, the ways in which a species perceives the physical world and the constraints of its physiology, when they frame behavioral questions. Proximate causes produce behaviors that evolve because they result in increased fitness, which is the ultimate cause of behaviors.

INTERACTIVE QUESTION 50.1

Many animals breed in the spring or early summer.

a. What is a probable proximate cause of this behavior?

b. What is the probable ultimate cause of this behavior?

■ Certain stimuli trigger innate behaviors called fixed-action patterns

Ethology, the study of how animals behave in their natural environment, originated in the 1930s. The work of Lorenz, Tinbergen, and von Frisch provided evidence for the innate components of behavior.

Fixed-Action Patterns A **fixed-action pattern (FAP)** is a highly stereotyped, innate behavior that, once begun, is usually carried through to completion. A FAP is triggered by a **sign stimulus** or **releaser**—some external sensory stimulus that, when perceived by the animal, initiates or "releases" a specific behavior.

The sign stimulus may be a feature of individuals of the same or another species. The releaser for attack behavior in stickleback fish is the red belly of the intruder. FAPs often are associated with interactions between parents and young, such as the begging and feeding behavior of many bird species. A limited subset of available sensory information usually elicits behavior in animals. Human behavior is usually based on more diverse, integrated information, which leads to intelligent action.

FAPs are adaptive responses that have evolved due to selection pressures. Finer discrimination among sign stimuli has evolved in situations where there has been strong selective pressure, as in the ability in certain species of birds to recognize foreign cuckoo eggs in their nests. Intelligence, the ability to learn from novel stimuli and adjust behavior based on this learning, may not have evolved in many animal groups due to the costs involved with the development and maintenance of neural tissue and the extension of juvenile phases with higher parental investment per offspring.

The mechanistic aspect of FAPs is illustrated by the repeated stereotyped behavior seen in some animals, such as a digger wasp performing its "drag and inspect" subroutine over and over when the paralyzed cricket it placed outside its nest is experimentally moved.

The Nature of Sign Stimuli The experiments of ethologists have shown that sign stimuli usually involve just one or two simple characteristics of the object or organism. The pecking behavior of a herring gull chick, for example, is released by the red spot on its parent's moving beak.

An animal's level of sensitivity to general stimuli correlates closely with the type of sign stimuli to which it responds. Frogs are quite good at detecting movement, and it is the movement of objects that releases the frog's feeding behavior. Experiments with *supernormal stimuli*, such as giant models of eggs, illustrate that stronger responses often are elicited by exaggerated sign stimuli.

Ethologists have suggested that the use of simple cues in the animal's environment to release pre-programmed behavior (FAPs) ensures behavioral responses that require the least amount of processing and integrating of input.

INTERACTIVE QUESTION 50.2

a. Give an example of a FAP in a human infant and the sign stimulus that illicits it.

b. The baby bird with the largest gape usually gets fed first. What is this an example of?

Learning is experience-based modification of behavior

Learning is the modification of behavior as a result of experience and can affect even innate behaviors.

Nature Versus Nurture Early European ethologists were studying innate aspects of animal behavior, while North American psychologists focused on how learning could influence behavior. The "nature versus nurture" debate concerns the relative importance of instinct and learning to behavior. Human language and bird songs are examples of learned behavioral variations of an innate ability.

Learning Versus Maturation Improved performance of innate behaviors may result from neuromuscular development called **maturation**. Birds prevented from flying until older are able, upon release, to fly without practice or learning.

Habituation A simple type of learning called **habituation** is the loss of sensitivity to unimportant stimuli or to stimuli not associated with appropriate feedback.

Imprinting Learning has a specific innate component in the phenomenon of **imprinting**. Mother–offspring bonding is critical for survival of offspring and for the reproductive fitness of the parent. The *imprinting stimulus* for newly hatched geese is the movement of an object, whether it be their mother, a ticking box, or Konrad Lorenz. The return of salmon to their home stream to spawn is an example of olfactory imprinting.

Imprinting is characterized by the irreversibility of learning and a limited **critical period** during which some type of imprinting may occur. The timing and duration of the critical period of sexual imprinting may vary.

The complex songs of male birds may advertise for mates, warn male competitors, announce group membership, or initiate group behaviors. Learning and genetic programming closely interact in vocal learning in young birds. In studies with experimentally raised white-crowned sparrows, a male bird raised in isolation developed a crude song called the template, a neural basis for the full adult song A bird learns to sing normally (i.e., to modify its template to the appropriate species' song) only if it can hear the song of its species during a critical period and then compare its own singing with the memory of that song. If a bird hears a taped song of only a related species during its critical period, it does not learn that song.

However, innate programming can be changed by experience. When sparrows older than 50 days can interact with singing adult birds of another species, the length of their critical period for learning songs is longer, and they are able to learn the song of the other species. People also have a critical period for learning vocalizations; learning foreign languages is easier up until the teen years.

Different species of birds show a great deal of diversity in their ability to learn songs. Some can develop nearly normal songs even when raised in isolation or deafened early in life.

Nottebohm's research has identified the forebrain region responsible for song learning in canaries. Changes in the size of this area correlate with the learning of new songs during the breeding season and the size of a song repertoire.

The diverse patterns of song acquisition among different groups of birds indicate that bird song is a fairly flexible behavioral system that has been shaped by natural selection and improves reproductive fitness.

Classical Conditioning In **associative learning**, animals learn to associate one stimulus with another. **Classical conditioning**, described through the work of Pavlov in the 1900s with salivating dogs, illustrates the association of an irrelevant stimulus with a fixed physiological response.

Operant Conditioning **Operant conditioning** refers to trial-and-error learning through which an animal associates a behavior with a reward or punishment. Skinner's work with rats is the best-known laboratory study of operant conditioning. The association of good or bad tastes with food items is probably a common form of operant conditioning in nature. A food's nutritive value may lead to the innate programming of good or bad taste through natural selection.

Observational Learning Many vertebrates learn by observing the behavior of others. Song development in birds illustrates this type of learning.

Play Species that engage in **play** often have a highly social lifestyle. Despite its use of energy and the risk of injury, play behavior is common because it may confer adaptive advantages. Play that simulates stalking and attacking may allow animals to practice these behaviors. Play also promotes muscular and cardiovascular fitness.

Insight **Insight learning**, sometimes called reasoning or innovation, involves the ability to perform correctly in a novel situation. Insight learning is most often observed in mammals, especially in primates, although such learning has been documented in some bird species.

INTERACTIVE QUESTION 50.3

Indicate the type of learning illustrated by the following examples:

a. Ewes will adopt and nurse a lamb shortly after they give birth to their own lamb but will butt and reject a lamb introduced a day or two later.

b. A dog, whose early "accidents" were cleaned up with paper towels accompanied with harsh discipline, hides under the bed any time a paper towel is used in the household.

c. Ducklings eventually ignore a cardboard silhouette of a hawk that is repeatedly flown over them.

d. Kittens stalk and pounce on each other, biting and kicking as they roll around together.

e. Chickadees that join large winter flocks learn flock-specific songs.

f. Ravens develop novel strategies to retrieve a food reward attached to a string.

g. In Pavlov's experiments, the ringing of a bell caused a dog to salivate.

Animal Cognition **Cognition** refers to an animal's ability to be aware of and make judgments about its environment. Because it is impossible to know what goes on inside the minds of animals, many researchers have taken a mechanistic approach to the study of animal behavior. Recently, Griffin and others have argued that conscious thinking is an inherent part of the behavior of many nonhuman, and even nonprimate, animals. According to **cognitive ethology**, cognitive ability forms an evolutionary continuum through many animal groups and has adaptive advantages that have been acted on by natural selection.

■ Rhythmic behaviors synchronize an animal's activities to daily and seasonal changes in the environment

Feeding, sleeping, reproducing, and migrating are all regularly repeated behaviors that show a temporal rhythm. The safe and profitable execution of such behaviors is the explanation for the ultimate causation of these rhythms. The proximate mechanisms are the subject of much study.

Animals, as well as plants, show circadian rhythms of roughly 24 hours. To determine whether these rhythms are based on *exogenous* (external) cues or *endogenous* (internal) timers, researchers have placed animals into environments with no external cues and observed that their rhythmic behaviors continue. An endogenous *biological clock* uses an exogenous cue, sometimes called a *Zeitgeber*, to keep the behavior timed with the real world. Humans living in free-running conditions with no external time cues have a biological clock with a period of about 25 hours.

The role of endogenous factors in **circannual behaviors**, such as reproduction, hibernation, and migration, is not well understood. These behaviors are based in part on physiological and hormonal changes linked with changes in day length. One of the few studies of endogenous control of these long-term behaviors has shown that fat deposition in ground squirrels, associated with hibernation, occurs regularly, even in a constant daylight cycle.

Some anatomical structure may serve as a pacemaker that controls behavioral rhythms. In mammals, the suprachiasmatic nucleus (SCN) in the hypothalamus receives nervous input from the retina and may produce proteins that regulate a variety of physiological functions involved in behavior.

■ Environmental cues guide animal movement

The ultimate cause for oriented movements is to bring animals to environments for which they are adapted. Much research has focused on the proximate causes or mechanisms that animals use to detect and respond to environmental cues.

Kinesis and Taxis A **kinesis** is a change in activity rate in response to a stimulus. Although kinetic movements are randomly directed, they tend to maintain organisms in favorable environments. A **taxis** is an oriented movement toward or away from a stimulus.

Migration Behavior **Migrations** are long-distance, regular movements, often involving a round trip each year. Three mechanisms may be used in migration: Traveling from one familiar landmark to another is called *piloting*. *Orientation* occurs when an animal detects compass directions and moves in a straight line. *Navigation* involves the ability to detect compass direction and to determine present location relative to destination (a "map sense").

Some species of birds and other animals orient by the heavens, using the sun or stars as directional cues. Many migrating animals use internal timing mechanisms to adjust to the changing positions of the sun and stars, both throughout the day and along the migratory route.

Many bird species are able to continue migrating under clouds or through fog, possibly because of their ability to detect and orient to Earth's magnetic field. Magnetite has been found in the heads of some birds, in the abdomens of bees, and in certain bacteria, although its role in sensing the earth's magnetic field has not been experimentally established.

INTERACTIVE QUESTION 50.4

a. What is the likely Zeitgeber for circadian rhythms?

b. What is the likely Zeitgeber for circannual behaviors?

c. How has the importance of endogenous mechanisms in rhythmic behavior been established?

INTERACTIVE QUESTION 50.5

Sow bugs are placed in experimental chambers that have light and dark areas and are either humid or dry. In the humid chamber, the sow bugs move into the dark area and stop moving. In the dry chamber, they move into the dark area and continue to move about in that area. Explain these experimental results.

■ Behavioral ecologists are using cost/benefit analysis to study foraging behavior

Some animals are generalists, feeding on a large variety of items, whereas others are specialists with quite restricted diets. Specialists usually have morphological and behavioral adaptations specific for their food, which makes them extremely efficient at foraging.

Generalists often concentrate on an abundant food item, developing a **search image** for it. Search images allow for short-term specialization while maintaining the advantages of being a generalist.

Behavioral ecologists study **foraging**, with the assumption that natural selection favors *optimal foraging*, choosing foods that maximize energy intake over expenditure. Factors involved in an optimal foraging strategy include the distance to a food item; the time and energy required to pursue, catch, and handle the item; the amount of usable energy and nutrients contained in it; and the risk of being preyed upon during feeding. Studies such as those on prey selection by bluegill sunfish have indicated that animals can modify their foraging behavior in ways that tend to maximize overall energy intake. This ability appears to be innate, although experience and physical maturation are thought to increase foraging efficiency.

INTERACTIVE QUESTION 50.6

What similarities and differences would you expect in the optimal foraging strategies of a generalist and a specialist?

■ Sociobiology places social behavior in an evolutionary context

Social behavior involves interaction between two or more animals, usually of the same species. Growing from the 1975 publication of E. O. Wilson's *Sociobiology*, the discipline of **sociobiology** uses evolutionary theory as the basis for studies of social behavior.

■ Competitive social behaviors often represent contests for resources

Agonistic Behavior **Agonistic behavior** involves a contest to determine which competitor gains access to a resource, such as food or a mate. The encounter may include a test of strength or, more commonly, threat displays and **ritual**, which serve to avoid actual physical conflicts. A display of submission or appeasement by one of the competitors inhibits further aggressive activity. The ending of a conflict without a violent combat avoids reducing the reproductive fitness of the winner as well as the loser. Scarcity of resources may result in more intense combat.

Dominance Hierarchies **Dominance hierarchies**, as illustrated by the "pecking order" of hens, prevent continual combat by establishing which animals get first access to resources. In wolf packs, the alpha female controls mating of the others, allowing them to mate if there is an abundance of food and preventing it otherwise.

Territoriality A **territory** is an area established for feeding, mating, and/or rearing young from which conspecifics are excluded. Territory size varies with species, function, and resource abundance. Agonistic behavior is used to establish and defend territories. A home range is the area in which an animal may roam, but a territory is the area that the animal defends. Vocal displays, scent marks, and patrolling may be used to continually proclaim ownership.

Dominance systems and territoriality help to stabilize population density by ensuring that at least some individuals have a sufficient supply of a limited resource in order to reproduce.

INTERACTIVE QUESTION 50.7

a. Why are many interactions between members of the same species agonistic?

b. What mechanisms reduce violent encounters between conspecifics?

■ Mating behavior relates directly to an animal's fitness

Courtship Most animals tend to view conspecifics as threatening competitors to be driven off. Complex courtship interactions, unique to each species, assure that individuals are not a threat and that they are of the proper species, sex, and physiological mating condition. These complex rituals often consist of a series of fixed-action patterns, each released in sequence by the reciprocal behavior of the other individual involved.

Courtship behavior may also function as a basis for mate selection. Females, who usually have more **parental investment** in each offspring due to greater time and resource allocation, usually show more discrimination in choosing mates than do males. Males often compete with each other for access to females. Intense courtship displays and secondary sexual characteristics may be used to attract females. If males provide parental care, a female's *assessment* of a specific mate may be based on the competence he displays. Vigorous courtship displays and extreme secondary sexual characteristics also may indicate good health. Especially if a male's only contribution to offspring is genetic, it is most beneficial to a female to choose a mate whose "performance" may indicate his genetic fitness.

Courtship and agonistic ritualized acts probably evolved from actions that originally had a more direct meaning in ancestral species.

Mating Systems Many species have **promiscuous** mating, with no strong pair bonds forming. Longer lasting relationships may be **monogamous** or **polygamous**. Polygamous relationships are most often **polygynous** (one male and many females), although a few are **polyandrous**.

The needs of young offspring are often an ultimate factor for the reproductive pattern of the parents. If young require more food than one parent can supply, a male may increase his reproductive fitness by helping to care for offspring rather than going off in search of more mates. With mammals, the female often provides all the food, and males are often promiscuous or polygynous.

Certainty of paternity also influences mating systems and parental care. With internal fertilization, the acts of mating and egg laying or birth are separated, and paternity is less certain than when eggs are fertilized externally. Natural selection has resulted in male parental care being much more frequent in species with external fertilization, where the male's genetic contribution to the offspring is more certain.

Molecular biology can determine paternity using DNA fingerprinting. Several studies have shown that extrapair copulations are common in many bird species that were previously believed to form monogamous pairs.

INTERACTIVE QUESTION 50.8

a. Which sex usually shows more discrimination in choosing potential mates?

b. Why might the sexes show differences in discrimination in mate selection?

■ Social interactions depend on diverse modes of communication

Communication is the intentional transmission of information between individuals using special behaviors called *displays*. A change in behavior of the "receiver" is an indication that communication has occurred. Whereas ethologists assumed that communication systems evolved in ways to maximize information transfer, behavioral ecologists believe that communications develop due to the benefits for the "sender." Deceptive communications are adaptive for the sender but not the receiver.

Communication may involve visual, auditory, chemical, tactile, and electrical signals, depending on the lifestyle and sensory specializations of a species. **Pheromones** are chemical signals commonly used by mammals and insects in reproductive behavior to attract mates and to release specific courtship behaviors.

Social or hive bees have highly complex communication systems, using ritualized dances to communicate the location of food sources. Round dances are used when the food source is relatively close to the hive. Regurgitated nectar provides a scent to direct other bees to the food. The location of more distant food is communicated by waggle dances, in which the duration and vertical orientation of the dance on the comb indicate the distance from the hive and the direction to the food relative to the horizontal angle to the sun. Additional research indicates that sounds and odors given off by the dancing bee may communicate information about the food resource.

INTERACTIVE QUESTION 50.9

a. Give an example of a deceptive communication.

b. Why is most communication among mammals olfactory and auditory, whereas communication among birds is visual and auditory?

■ The concept of inclusive fitness can account for most altruistic behavior

Many social behaviors are selfish, benefiting an individual at the expense of others. **Altruism** is behavior that reduces an individual's fitness while increasing the fitness of the recipient. In the 1960s, Hamilton explained altruistic behavior in terms of **inclusive fitness**, the ability of an individual to pass on its genes either by producing its own offspring or by helping close relatives produce their offspring. The *coefficient of relatedness* is a measure of the proportion of genes shared by two related individuals. **Kin selection** suggests that altruistic behavior is strongest between close relatives and less common as genetic relatedness decreases. Studies show that most cases of altruistic behavior involve close relatives and thus improve the individual's inclusive fitness.

When altruistic behavior involves nonrelated animals, the explanation offered is **reciprocal altruism**; there is no immediate benefit for the altruistic individual, but some future benefit may occur when the helped animal may "return the favor." Reciprocal altruism often is used to explain altruism in humans.

INTERACTIVE QUESTION 50.10

a. According to kin selection, would an individual be more likely to exhibit altruistic behavior toward a grandparent, a sibling, or a first (full) cousin?

b. Explain your answer in terms of the coefficient of relatedness.

Human sociobiology connects biology to the humanities and social sciences

In *Sociobiology*, Wilson speculated on the evolutionary basis of certain social behaviors of humans. The sociobiology debate continues the nature-versus-nurture controversy. Some sociobiologists explain that cultural and genetic components of social behavior are linked together in a cycle of reinforcement. The development of cultural regulations of innate behaviors serves as an additional factor for the natural selection of that behavior. According to this view, human behavior represents an integration of genes and culture.

The parameters of human social behavior may be set by genetics, but the environment undoubtedly shapes behavioral traits just as it influences the expression of physical traits. Due to our capacity for learning and integration, human behavior appears to be quite plastic. Our structured societies, with their regulations on behaviors, including behaviors that would enhance an individual's fitness, may be the one unique characteristic separating humans and other animals.

STRUCTURE YOUR KNOWLEDGE

1. How does the nature-versus-nurture controversy apply to behavior?
2. How does the concept of Darwinian fitness apply to behavior?

TEST YOUR KNOWLEDGE

MULTIPLE CHOICE: *Choose the one best answer.*

1. Behavioral ecology is the
   a. mechanistic study of the behavior of animals, focusing on stimulus and response.
   b. application of human emotions and thoughts to other animals.
   c. study of animal cognition.
   d. study of animal behavior from an evolutionary perspective of Darwinian fitness.
   e. consideration of an animal's *umvelt* when considering the ultimate cause of behavior.
2. Proximate causes
   a. explain the evolutionary significance of a behavior.
   b. are immediate causes of behavior such as environmental stimuli.
   c. indicate that much of animal behavior is innate.
   d. are endogenous, although they may be set by exogenous cues.
   e. show that nature is more important than nurture.
3. Supernormal stimuli
   a. may elicit stronger responses or FAPs.
   b. are innate releasing mechanisms between individuals of the same species.
   c. are illustrated by the removal of the cricket from near a digger wasp's nest.
   d. are illustrated by the bobbing of a stick with a red spot past herring gull chicks.
   e. are illustrated by the imprinting of goslings on Konrad Lorenz.
4. Which of the following is an example of the evolution of a fixed-action pattern with finer discrimination among sign stimuli?
   a. a bluegill sunfish feeding on larger *Daphnia* when prey are abundant
   b. a chick pecking at the red spot on a parent's moving beak
   c. a bird recognizing and expelling an egg of a cuckoo from its nest
   d. a songbird learning its song after listening to a taped song of its species
   e. a bird learning to avoid monarch butterflies

5. A change in behavior as a result of experience is called
   a. habituation.
   b. imprinting.
   c. insight.
   d. learning.
   e. maturation.

6. A critical period
   a. is the time right after birth when sexual identity is developed.
   b. usually follows the receiving of a sign stimulus.
   c. is a limited time during which imprinting can occur.
   d. is the period during which birds can learn to fly.
   e. is the time during which social animals play.

7. In classical conditioning,
   a. An animal associates a behavior with a reward or punishment.
   b. An animal learns as a result of trial and error.
   c. Sensitivity to unimportant or repetitive stimuli occurs.
   d. A bird can learn the song of a related species if it hears only that song.
   e. An irrelevant stimulus can elicit a response because of its association with a normal stimulus.

8. Circannual behaviors
   a. are often linked to changes in day length.
   b. rely solely on endogenous cues.
   c. involve foraging, reproduction, and migration.
   d. do not occur in free-running conditions.
   e. have a rhythm of 24 hours that is based on exogenous cues and endogenous timers.

9. A kinesis
   a. is a randomly directed movement that is not caused by external stimuli.
   b. is a movement that is directed toward or away from a stimulus.
   c. is a change in activity rate in response to a stimulus.
   d. is illustrated by trout swimming upstream.
   e. often involves piloting but not orientation or navigation.

10. A dominance hierarchy
   a. may be established by agonistic behavior.
   b. determines which animals get first access to resources.
   c. helps to avoid potential injury of competitors.
   d. may help to stabilize population density.
   e. applies to all of the above.

11. An animal's territory
   a. may be larger than its home range.
   b. may decrease in size if resources dwindle and expand if resources become more plentiful.
   c. excludes both conspecifics and members of other species.
   d. may be proclaimed by scent marks, vocal displays, and patrolling.
   e. applies to all of the above.

12. In a species in which females provide all the needed food and protection for the young,
   a. Males are likely to be promiscuous.
   b. Mating systems are likely to be monogamous.
   c. Mating systems are likely to be polyandrous.
   d. Males most likely will show sexual selection.
   e. Females will have a higher Darwinian fitness than males.

13. The ability of honeybees to fly directly to a food source, after having to wait several hours from the time of the waggle dance, indicates that
   a. The waggle dance provided directions relative only to the position of the hive.
   b. Bees have an internal clock that compensates for the movement of the sun during the elapsed time.
   c. The bees must have been to that food source before.
   d. Bees are directed more by olfactory cues than by directional cues.
   e. The intensity of the dance provided directional cues.

14. The concept of inclusive fitness explains
   a. optimal feeding behavior.
   b. sexual selection.
   c. kin selection and altruistic behavior.
   d. monogamous mating systems.
   e. the coefficient of relatedness.

15. Sociobiology
   a. explains the evolutionary basis of behavioral characteristics within animal societies.
   b. applies evolutionary explanations to human social behaviors.
   c. studies the roles of culture and genetics in human social behavior.
   d. considers communication and mating systems from the viewpoint of Darwinian fitness.
   e. does all of the above.

CHAPTER 50
BEHAVIOR Solutions

INTERACTIVE QUESTIONS

50.1 a. The stimulus of an increase in day length may result in reproductive behavior.
b. Breeding is most successful during this time due to warm temperature and food supply.

50.2 a. An infant's smile and grasp are FAPs in response to visual or tactile stimuli.
b. A stronger response to an exaggerated sign stimulus.

50.3 a. imprinting
b. operant conditioning (associative)
c. habituation
d. play
e. observational learning
f. insight
g. classical conditioning (associative)

50.4 a. light or lack of light
b. day length
c. Experimental animals kept in constant light, dark, or day-length conditions continued to show rhythmic behaviors or physiological changes.

50.5 The sow bugs were showing negative phototaxis and a kinesis for relative humidity.

50.6 Both types of feeders would be expected to maximize energy intake over expenditure by somehow factoring in such things as the size of prey and relative abundance of different sizes; distance to the prey and the energy required to catch it; and risk of becoming prey while feeding. In addition, the generalist might compare the relative abundances of different types of prey, and foraging efficiency could be improved with the development of a search image for specific prey. The specialist often has anatomical and behavioral adaptations for feeding efficiently on one type of food item.

50.7 a. Members of the same species occupy the same niche and are thus competitors for resources such as food, territory, and mates. In agonistic encounters, one animal may establish its claim to these resources.
b. ritual behavior (threat displays, appeasement gestures), dominance hierarchies, and territories

50.8 a. female
b. Females usually have more parental investment in offspring due to the larger resource allocation in eggs and maternal care. Their reproductive fitness is improved by selecting mates that provide offspring with good genes or competent paternal care. A male has little resource commitment in sperm and may potentially improve his fitness by mating as often and with as many partners as possible.

50.9 a. plover fake injury display; female fireflies flashing male of another species and eating him; pregnant Asian monkey soliciting copulation with new dominant male
b. Mammals are mostly nocturnal; birds are diurnal.

50.10 a. a sibling
b. The individual shares more alleles in common with a sibling ($r = 0.5$); r for a grandparent is 0.25, and r for a cousin is 0.125.

Suggested Answers to Structure Your Knowledge

1. There is controversy over how much of animal behavior is innate and genetically programmed and how much is a product of experience and learning. Fixed-action patterns are clearly preprogrammed behavior, and many seemingly complex animal behaviors can be isolated into a series of FAPs. In other cases, genetics may set the parameters for an organism's behavior; however, experience can modify behavior, and learning is clearly evident.
2. According to the concept of Darwinian fitness, an animal's behavior should help to increase its chance of survival and reproduction of viable offspring. Survival behaviors that are genetically programmed would be most likely to be passed on, and species would evolve many innate behaviors for foraging, migrating, mating, and care of offspring. The evolution of cognitive ability would help individuals deal with novel situations. Social behaviors and communication may help reduce potentially harmful competition. Parental investment and certainty of paternity may result in differences in mating systems and parental care that influence an individual's reproductive success. Altruistic behavior has been explained on the basis of kin selection; the inclusive fitness of an animal increases if its altruistic behavior benefits related animals who may be carrying a high proportion of the same alleles.

Answers to Test Your Knowledge

Multiple Choice:

1. d	6. c	11. d
2. b	7. e	12. a
3. a	8. a	13. b
4. c	9. c	14. c
5. d	10. e	15. e

MATERIAL: SCIENCE WORLD

SIBLINGS

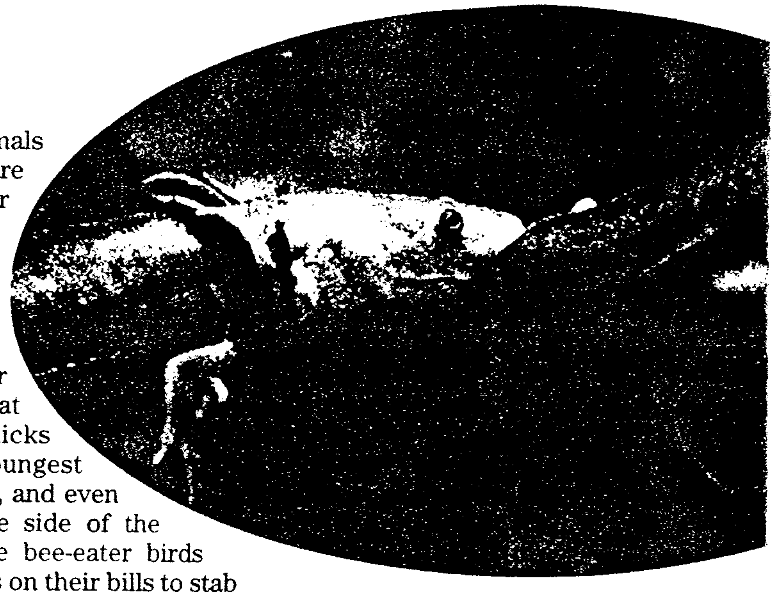
Think you have a hard time getting along with your brothers and sisters? Check out these extreme examples of sibling rivalry in the animal world.

by Maria L. Chang

If you trade insults with your brother or sister every waking moment, you might think you have the worst sibling relationship on Earth. Think again! Some members of the animal kingdom take sibling rivalry to the max. They *kill* their brothers and sisters to survive!

Murdering a sibling, or *siblicide*, may seem cruel. Fortunately it's not the most common behavior in the animal kingdom. In fact, many animals have amicable sibling relationships (*see* "Family Bonds," *p. 10*). But when there's a short supply of food, some birds, insects, fish, and mammals snare their share by killing their closest competitors—their siblings.

Scientists have known for years, for example, that great egret chicks peck their youngest sibling to death, and even toss it over the side of the nest. And some bee-eater birds use sharp hooks on their bills to stab their siblings.



Tiger salamanders, like some other amphibians, may dine on siblings when food is in short supply.

Robert Caputo/Aurora

Spotted hyena cubs start fighting moments after they're born. The conflict between same-sex twins often continues until one cub dies.

Now, recent studies show that some animal parents actually "promote" siblicidal behavior! Why would parents be so heartless? Because siblicide may help the parents keep their genes alive.

When parents have babies, the offspring inherit the parents' genetic material. But for genes to live on, the offspring must be fit enough to survive and reproduce themselves. And under certain circumstances—say, when food is in short supply—fewer offspring may be the parents' best bet.

Great egrets and cattle egrets, for example, often have enough food for only two chicks, although a mom egret typically bears three. By sometimes allowing their older children to kill the youngest, the parents guarantee that they raise two well-fed, strong chicks who have an excellent chance to mature and reproduce.

David W. Pfennig

In fact, new research shows that the two oldest cattle egret chicks are destined for success even before birth, says behavioral ecologist Douglas Mock. Mock and colleague Hubert Schwabl recently discovered that the first egg to form inside the mother egret always gets the highest dose of the *hormones*, or chemical messengers, that trigger aggressive behavior. The second egg in line gets the same dose. But egg number three gets only about half the amount. With less tendency to be aggressive, the youngest chick is less able to defend itself against its more aggressive siblings.

So why do egrets even bear a

Family Bonds

Howard Hall/Oxford Scientific Films/Animals Animals

Lion cubs engage in "mock fights" to practice their hunting skills.

Cruel as some animal brothers and sisters can be, many animals help their siblings.

Take lion cubs. As they swat at each other, they look like they're fighting. In reality, they're playing and giving one another hunting practice. Before they engage in a mock battle, the cubs walk around each other in a submissive manner to signal that the fight is not for real. Then they strike with retracted claws, careful not to hurt each other.

Cotton-top tamarins, squirrel-sized monkeys that live in large family groups, *do* sometimes fight—over who gets to babysit newborn siblings. There's a reason for their nurturing behavior. By caring for younger siblings, tamarins become parents-in-training. "Tamarins that have not had [caretaking] experience in the family group usually fail as parents," says animal psychologist Gretchen Achenbach.

Sea turtles and many other reptiles, on the other hand, are indifferent to their siblings. When predatory birds and animals grab at newly hatched turtles on a beach, the hatchlings scurry to reach the open sea—each turtle for itself. The lucky few who survive go their separate ways and never see their siblings again.

Do any of these sibling relationships describe how you interact with your brothers or sisters? [illegible]

third chick? The youngest chick serves as "insurance," Mock explains. If something happens to either of the older chicks—say a gull swoops down and carries one away—then the youngest chick can take its place. The parents still end up with two chicks to pass on their genes.

SIBLINGS FOR LUNCH

Some amphibians solve the food-shortage problem in a more direct way: They *eat* their siblings.

Most spadefoot tadpoles feed on algae. But sometimes, a tadpole eats another tadpole. This nutrient- and hormone-rich meal makes the tadpole grow and changes its appetite. The cannibal tadpole develops enormous jaws and gorges exclusively on other tadpoles.

The cannibal tadpoles are *usually* careful to eat only *nonrelatives*, says biologist David Pfennig. They nip at tadpoles that swim by and conduct chemical "taste tests" to determine if they are kin. If the large-jawed tadpoles accidentally swallow a sibling, they immediately spit it out.

But if food is scarce, the cannibals cease to discriminate. Then they eat any tadpole that crosses their path, whether it's a sib or not.

Cannibalistic siblicide can even begin before birth. Sand tiger sharks, for example, eat their brothers and sisters *inside* their mother's womb!

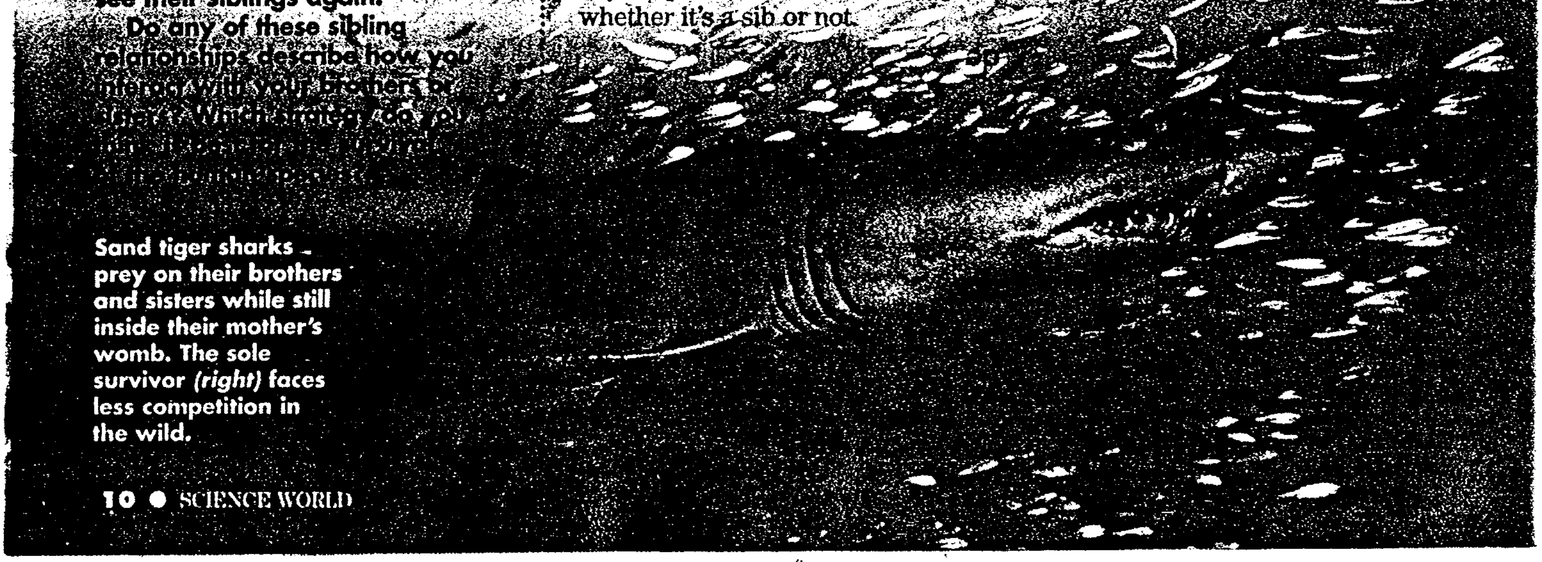
A female sand tiger shark produces 400 to 500 embryos at a time. While still in the womb, these embryo sharks grow razor-sharp teeth, says marine biologist John Wourms. The embryonic sharks start to eat other embryos. Within a few months, three to four dominant sharks engage in a life-or-death struggle until only one survives. By the time it is born, the sole-surviving shark pup has become an experienced predator.

TWIN TROUBLE

Spotted hyena cubs don't have to kill their siblings for food. They get a continuous supply of milk from their mother. But same-sex *twins* always fight to eliminate a potential rival for mates or social rank in the clan.

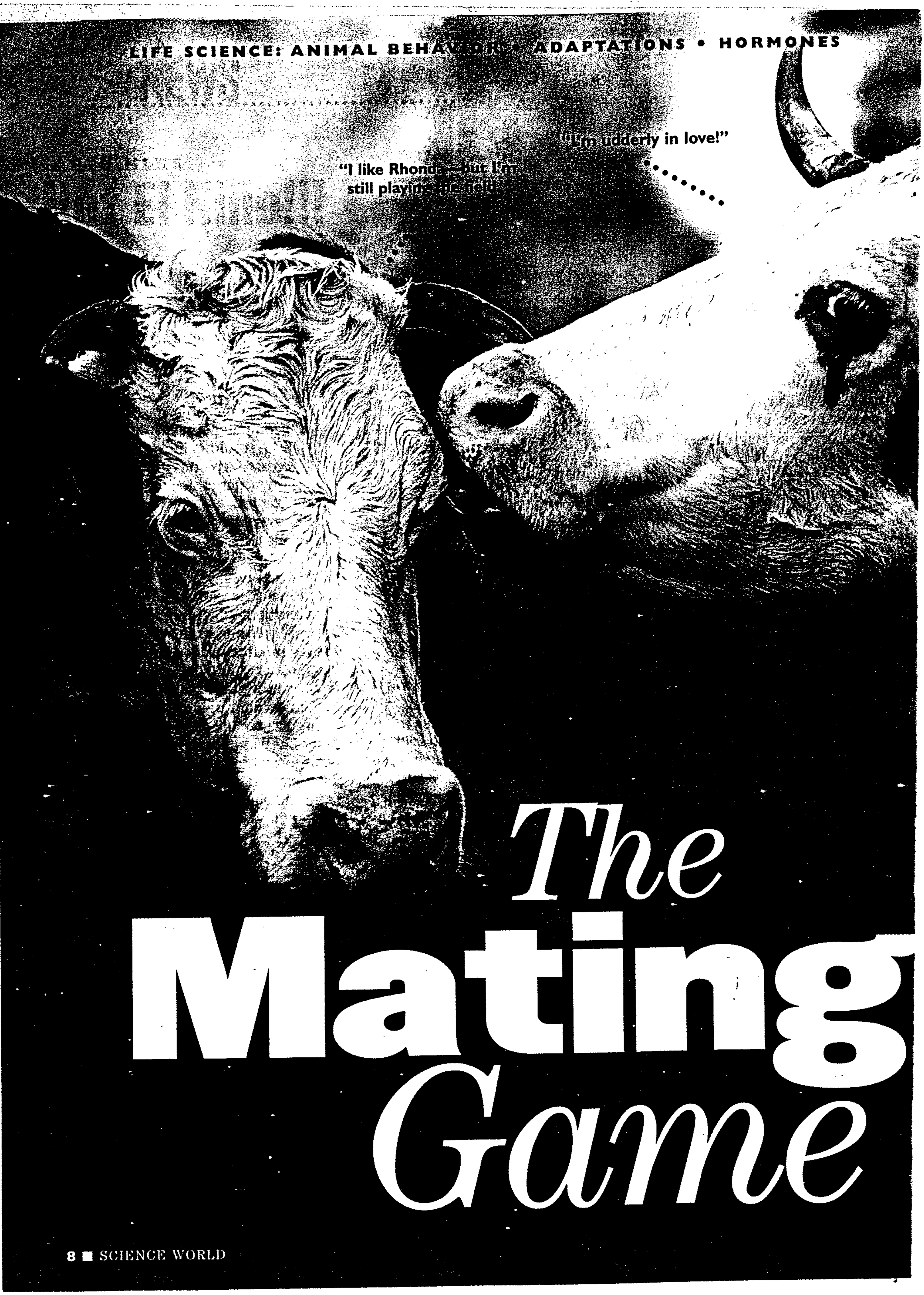
This competition starts soon after the hyena twins are born. While hidden inside its burrow, the older cub clamps down on its younger twin's neck and violently shakes the cub. But the older twin is not always the victor, says biologist Laurence Frank. The younger one often fights back, initiating a fierce battle that can last for weeks. In the end, the weaker sibling may die from badly infected wounds and even mal-nourishment. The victor emerges from the burrow, ready to join the hyena clan.

Just remember, siblicide is usually a last resort in times of desperation. Mock says it's as if animals *know* conditions aren't going to get any better and "think," "One of us is going to have to die and it's not going to be me!" ■



Rosing/Animals Animals

Sand tiger sharks prey on their brothers and sisters while still inside their mother's womb. The sole survivor *(right)* faces less competition in the wild.



The Mating *Game*

From cows to prairie voles (*top right*), hormones play a key role in leading mammals down lover's lane.

by Chana Stiefel

It's Saturday night. You style your hair, spray on deodorant, and gurgle mouthwash. You tear through your closet for your best jeans, then perform the curious ritual of checking yourself over and over in the mirror. What's it all about? Romance, of course.

On Saturday nights the world over (and every other day of the week, for that matter), Romeos and Juliets of the animal kingdom—from ants to zebras—are also preening and "dating." Now biologists are discovering how brain chemistry affects animal mating styles, and are piecing together the many meanings of animal courtship rituals. Their consensus: Animals and humans who "fall in love" share more traits in common than ever believed.

For starters, new research shows that some mammals release *hormones* (chemicals that affect body functions) like those of humans falling in love. Also, many animals "flirt" just like teens—they dance, sing, dress up, offer gifts, spray chemical perfumes and, yes, even fight over each other. To top it off, biologists are finding that the "show-off" antics many male animals perform to nab mates serve a vital purpose: The female gets to judge just how suitable her admirer is before making any commitment—and mating with him.

Scientists now think the capacity for love is programmed into animal biochemistry—especially hormones.

Male bottlenose dolphins literally flip over females to keep them interested. Some gang up on other males to steal away females.

Animals and plants produce hormones in very small amounts, which have powerful effects on their organs and systems. Humans, for example, produce 30 hormones in various body organs, called *endocrine glands*, as well as in the brain and kidneys. Without hormones our bodies wouldn't grow or mature sexually. Hormones actually cause our hearts to speed up under stress, and help the body convert food into energy. When it comes to the role of hormones in choosing mates, scientists have recently zeroed in on the brain.

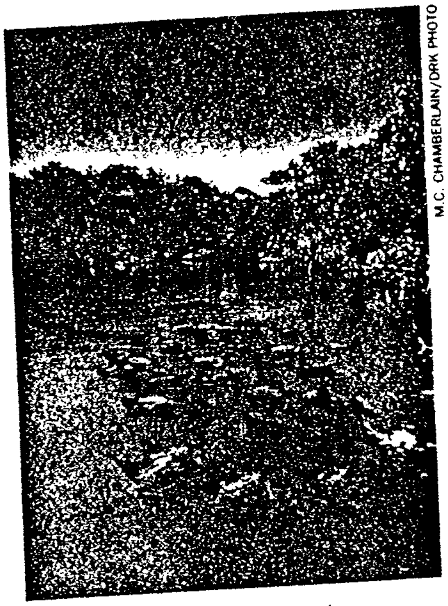
ROMANCE?

Take the prairie vole, a fluffy rodent that sticks with the same mate for life. When single voles meet, the female's brain releases a heightened dose of the hormone *oxytocin*, explains Sue Carter, a zoologist at the University of Maryland. Scientists have known since 1906 that oxytocin stimulates human female contractions during childbirth. Now they think the hormone also acts as a *neurotransmitter*, or chemical messenger in the brain's nerve cells, that can guide behavior and seal emotional ties. When

COWS: BRYAN REINHART/MASTERFILE; DOLPHIN: STEVE BLOOM/MASTERFILE

Male sea horses get pregnant and give birth! During the seven-month breeding period, a male sea horse may become pregnant 12 times and spawn 200 offspring.

PAUL A. ZAHL/PHOTO RESEARCHERS, INC.



M.C. CHAMBERLAIN/DRK PHOTO

Female stingrays hang out together in groups up to 50. The "guys" hone in on the females' electric signals and circle the girls, looking for love.

oxytocin courses through the female vole's brain, she bonds with the male. Deprived of the hormone (in the lab), she ignores him!

Similarly, the male vole's brain releases *vasopressin*, a hormone that prompts him to bond with his mate and guard her and their young from predators. "You can't imagine how much time these animals spend together," Carter says. "They spend over half their time sitting quietly touching each other. The release of hormones seals the bond." If that isn't romance, what is?

HOW TO GET A DATE

Species of all kinds also exhibit what scientists call *social behavior*—they interact with each other in a wide variety of courtship rituals.

Sea horse pairs start each day by wrapping their tails around each other and performing a tango around a blade of grass. Some scientists believe that sea horses remain forever faithful to their mates. They've tried to persuade male and female sea horses to "cheat" in a tank full of sea horse "singles." But "married" sea horses seem to only have eyes for each other. (Perhaps most amazing is that *male* sea horses get pregnant and give birth!)

The next generation of sea horses will repeat their parents' romantic rituals. Scientists say that courtship behavior is often passed down from generation to generation. For creatures like sea horses, who spend no time with their parents after birth, courtship behavior is pure genetics, the result of "dance steps" passed down from one generation to another. *Genes* are chemical instructions in animal cells received from mom and dad. Of course, some young mammals pick up "dating" tricks by simply imitating their parents.

Courtship strategies evolve over long periods of time, usually based on what "works" for each species to survive, says Penny Kalk, a mammalogist at the Bronx Zoo in New York. These genetically inherited traits are known as *adaptations*. Evolution helps explain how cats of all kinds—from kittens to Siberian tigers—have adapted the same mating rituals. In a courtship dance, "the female runs, rolls, and lifts her rear up in the air," Kalk says. Apparently this "dance" evolved among biological ancestors of female felines to attract "cool cats."

Other animal courtship adaptations abound. You may surprise your date with flowers or candy. Male bowerbirds in Australia and New Guinea have inherited the know-how to build lavish bowers—walled chambers made of twigs, decorated with blue feathers, yellow flowers, and leaves. A choosy female "can come in close, check out the male, and make sure she's making the right decision," says Gerald Borgia, a zoology professor at the University of Maryland.

STINGING LOVE

Talk about "electric" love! Stingrays are flat fish with whiplike tails that have adapted a sensory system known as *electroreception.* A weak electric current flows from tissues in a ray's mouth, gills, and other body parts. Seawater acts like a three-dimensional wire, conducting the current through the surf. During mating season, females pile up in groups up to 50 rays high, forming "condominiums" in the sand. When females give off electric signals, males use their own electrical receptors to hone in on them. The

Mother Love

How did love begin? Probably with motherhood. All across the animal kingdom, mothers nurture their offspring, making sure babies get off to a good start. An orangutan mom *(below)* cares for her baby for four years. Then the toddler is ready for "independence day."

In mammals and possibly other animals a hormone called *oxytocin,* released in the mother's brain during labor, is a spark bonding mother to child. Oxytocin blunts the physical pain of childbirth and induces sensations of pleasure. Without it a ewe, for example, can't recognize her own lamb.

In many species other than mammals, however, moms aren't so loving. In general, insects, fish, turtles and other species that produce many eggs (and thus many offspring) provide little care—the more young that are born, the better the odds for survival of the species. The more loving moms, like mammals, are those who produce fewer offspring.

In a bloody battle over females, male elephant seals bellow warning calls. If that doesn't work, these heavyweights slam against each other and sink their teeth into fatty flesh.

KENNAN WARD, DRK PHOTO

males then circle the condos and try to pull out females for mating.

If you find the scent of cologne alluring, you're not alone. Since the female gypsy moth can't fly, she manufactures her own natural "perfume" to attract a far-away male. She releases chemicals called *pheromones* from a gland on her abdomen. The pheromones waft into the air, carrying a specific scented signal that lures only male gypsy moths. The male's antennae, each one covered with 15,000 pheromone-sensitive hairs, can detect a single molecule of the scent from as far as seven miles away!

DATING DANGERS

Sometimes the contest for mates gets downright nasty. Male elephant seals are cow-size mating machines that often claim a harem of 50 females. Once landing on a beach to mate, males test each other's strength to fight over females. Males let out loud warning cries to keep rivals away. If their alarm fails, watch out! Males slam their chests against rivals and rip at their necks with long canine teeth, resulting in a bloody bout. The loser flees—without the girl.

The mating game can also be deadly. At the sight of a female, a male praying mantis freezes in place. He gradually but cautiously moves toward her. Then he jumps on her and begins to mate. During mating, the female may twist around, bite off the male's head and eat it!

Why do animals—including humans—go through such trouble to find their mates? Biologists say that the strongest drive in any creature is the desire to preserve one's genes for eternity. "The bottom line is getting your genes passed on to the next generation," explains zoologist Borgia. Animals feel the need to pass on genes in the form of offspring, even if it means getting dumped, bruised, or beheaded. The species that try hardest have the best chance of survival. So dating and mating are a natural part of life on Earth.

Happy Valentine's Day! ■

hands on science Call of the Wild

How do animals find mates of their own species?

WHAT YOU NEED

• film canisters with lids (one per student) • small objects (paper clips, pennies, popcorn kernels, marbles, dried macaroni pieces, etc.) • paper bag

WHAT TO DO

1. Divide up the canisters into pairs.
2. Choose which of the following items to put in each canister pair: • 3 paper clips (per canister) • 2 pennies • 1 marble • 2 popcorn kernels • 4 macaroni pieces • anything else that makes a different noise when shaken in the canister. (Put the lid on first!) More than one pair can contain the same objects.
3. Put the lids on, and drop the canisters into a bag.
4. Each student in the class should take one canister from the bag.
5. Walk around the room, shaking your canister. Listen carefully to other students' canisters. When you find a sound match, sit down with your "mate."

CONCLUSIONS

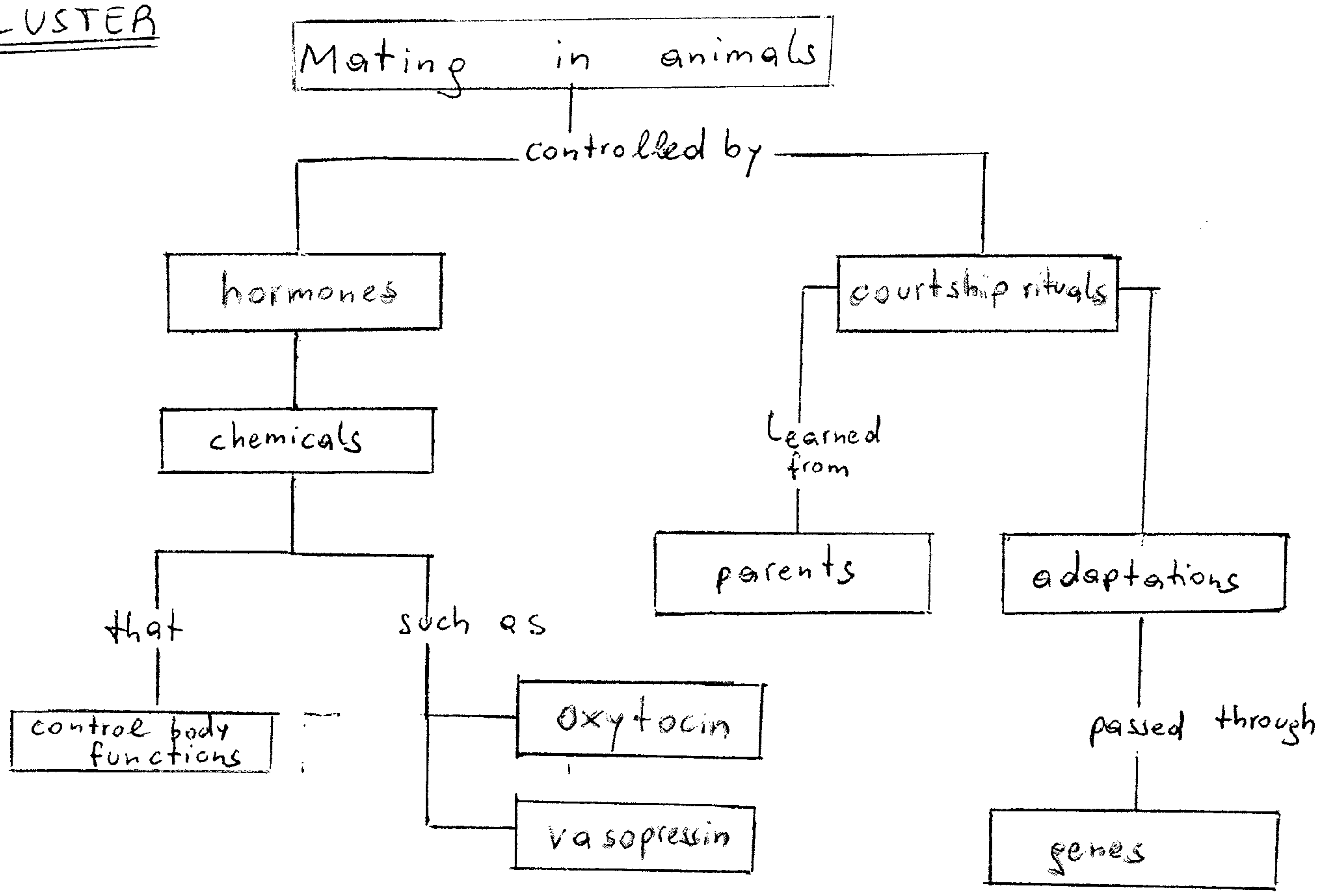
How many of you found "mates"? How is the activity similar to what animals do in the wild? When is sound a more reliable way to find mates than sight?

THE MATING GAME WORDS

preen - putzen
nab - schnappen
vole - Wühlmaus
udder - Euter
feline ['fi:laɪn] Katzen, katzenartig
ray - Rochen
spawn - Laich
gill [gɪl] - Kiemen (gill [dʒɪl] - Liebste)
surf - Brandung
ewe - Mutterschaf
waft into [wa:ft] - wehen, schweben
praying mantis - Gottesanbeterin
kernel - Kern, Innerstes
glands - Drüsen

<u>READING CLUSTER</u>

THE MATING GAME



QUESTIONS

1. How are sea horses similar to and different from humans in their mating behaviour.
2. Explain how a female gypsy moth attracts a mate.
3. What male animals may resort to violence to attract a female?
4. Which animal's mating ritual would be unacceptable in our society? Why?

THE MATING GAME

VOCABULARY BUILDER

Name: ____

Looking for Love

K	L	G	E	D	W	B	N	B	H	B	N	P	Z
S	W	V	N	I	C	O	T	Y	X	O	R	H	T
E	S	O	D	M	L	Z	R	P	W	A	K	E	P
A	T	I	O	R	Y	E	O	P	Y	M	R	R	A
H	I	Y	C	L	I	R	F	I	H	H	M	O	S
O	N	B	R	N	M	B	N	T	Y	R	E	M	N
R	G	U	I	O	Y	G	R	N	X	E	W	O	I
S	R	N	N	F	M	Z	N	E	Q	I	O	N	H
E	A	E	E	A	R	G	E	D	W	P	O	E	P
S	Y	E	N	S	E	N	O	M	R	O	H	S	L
X	S	T	E	V	R	I	O	L	K	Y	B	T	O
J	I	M	X	C	Z	E	D	R	W	Q	O	P	D
S	L	O	G	G	Y	P	S	Y	M	O	T	H	A
P	R	Z	E	J	U	V	M	L	I	C	N	D	O

Directions: Solve the clues below. (HINT: The number in parentheses tells you how many letters are in each word of the answer.) Then find and circle the words in the word-search grid. The words can run up, down, diagonally, backward, or forward.

1. Glands that produce 30 human hormones. (9)
2. When this hormone is present, female prairie voles bond with males. (8)
3. These animals entwine tails when they dance with their mates. (3) (6)
4. Attraction between these animals is "electric." (9)
5. The female of this insect species releases a scent to attract males. (5) (4)
6. Perfume used by many members of the animal kingdom. (10)
7. This male insect risks losing his head while mating. (7) (6)
8. This animal's "bachelor pad" helps attract females. (9)
9. Chemicals that help humans mature sexually and choose a mate. (8)
10. These mammals gang up to steal females away from other males. (8)

Answers on pages TE3 and TE8.

LESSON PLAN

1) INTRODUCTION
   a) brainstorming
   b) collecting jungle words
   c) mix and match exercise
   d) spidergrams
   e) central idea graph

2) HANDOUTS
   ·) reading (homework)

3) ACTIVITIES
   a) animal game
   b) drawing of food webs
   c) animal wordsearch / plant sheet
   d) handout: How many animals can you spot?

4) POSTERS
   (students produced posters to given topics e.g. birds in the rainforest, people in the rainforest, ...)

5) SUMMING UP

   TASKS (handouts)
   a) Complete the sentences.
   b) Put together the beginnings and endings of sentences

   REVISION (handouts)
   a) yes/no answers to statements
   b) questions – How much can you remember?
      More questions

   ACTIVITIES
   a) Visit a pet shop
   b) Write letters to two organizations

ACTIVITIES

Mix and match

1. carbon dioxide
2. destroy
3. extinction
4. insect
5. malaria
6. oxygen
7. scientist
8. soil
9. species
10. vapour

a) gas-like form of a liquid, formed when the liquid is heated

b) group of similar animals or plants

c) the ground in which plants grow

d) a person who studies the Earth and how things work

e) gas without colour, taste or smell, which is in the air and which we need to live

f) illness passed on by mosquitoes

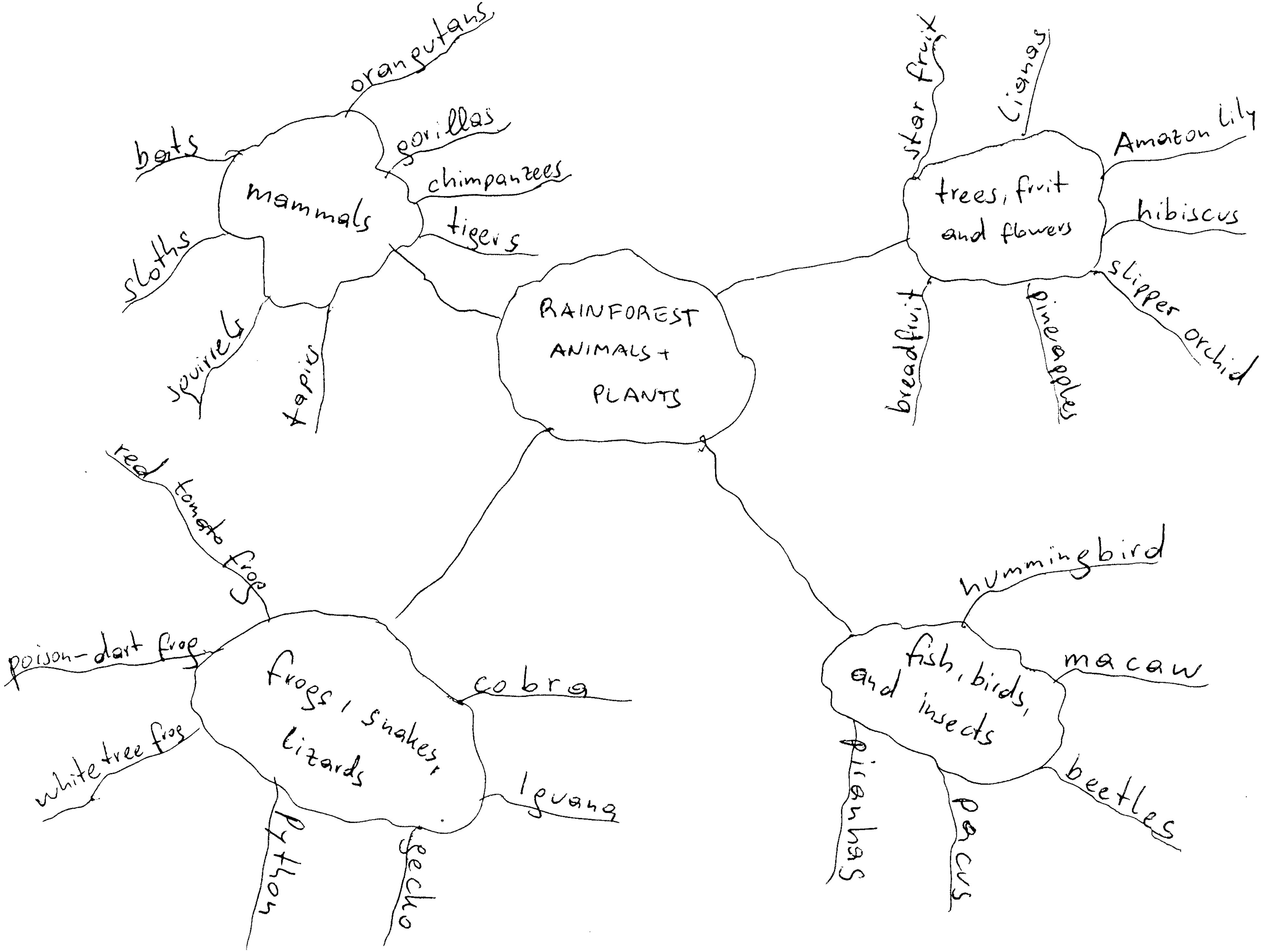
g) small animal with <u>six</u> legs

h) completely died out

i) to damage something very badly

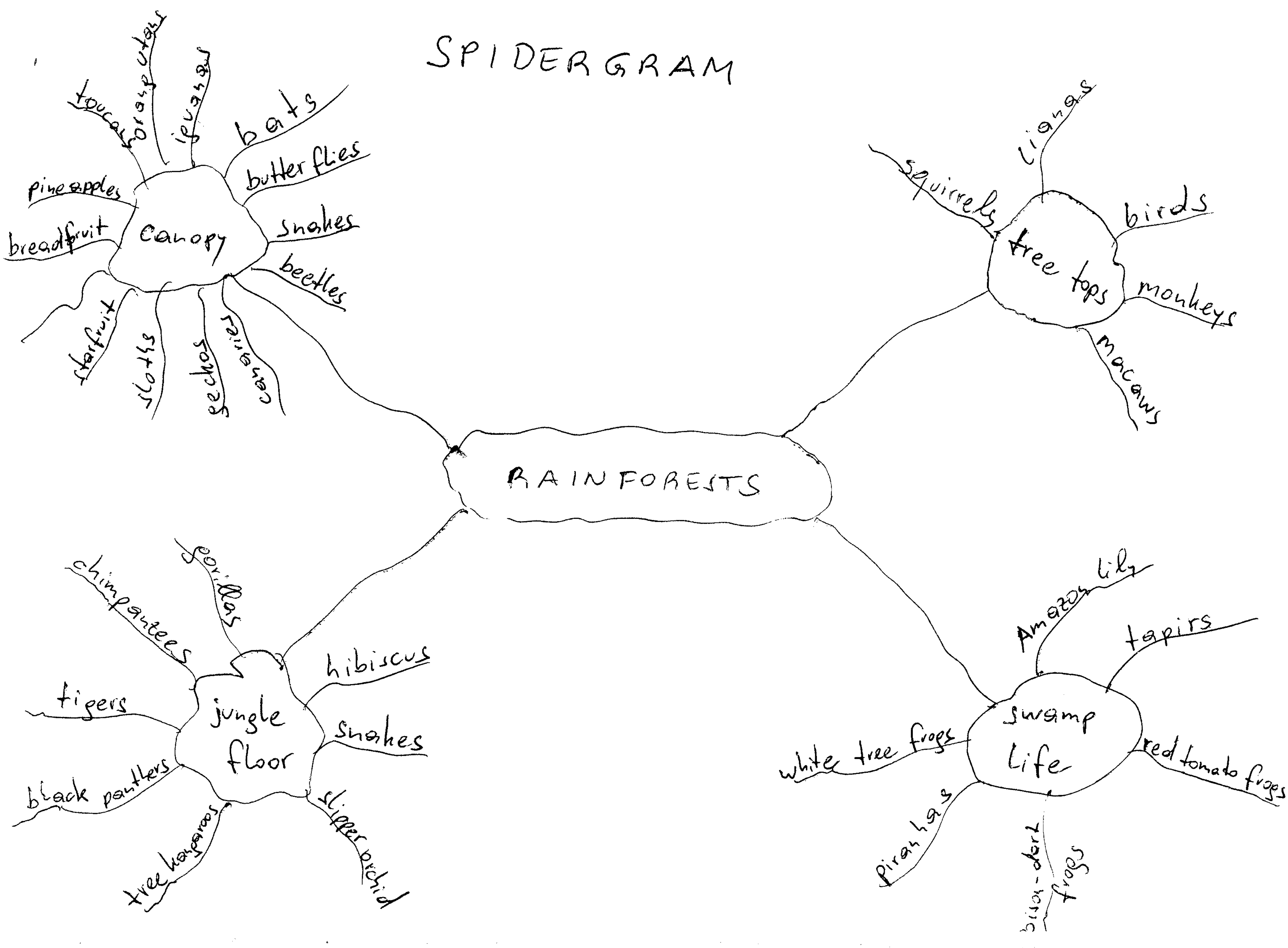
j) gas produced by animals and breathed out with the air

SPIDERGRAM



RAINFOREST ANIMALS + PLANTS
mammals
bats
oranguntans
gorillas
chimpanzees
tigers
sloths
squirrels
tapirs
trees, fruit and flowers
star fruit
lianas
Amazon lily
hibiscus
slipper orchid
pineapples
breadfruit
frogs, snakes, lizards
red tomato frog
poison-dart frog
white tree frog
cobra
iguana
Python
gecko
fish, birds, and insects
hummingbird
macaw
beetles
pacus
piranhas

SPIDERGRAM



RAINFORESTS
canopy
toucans
orangutans
iguanas
bats
butter flies
pineapples
snakes
breadfruit
beetles
starfruit
sloths
geckos
canaries
tree tops
lianas
squirrels
birds
monkeys
macaws
jungle floor
chimpanzees
gorillas
hibiscus
tigers
snakes
black panthers
tree kangaroos
slipper orchid
swamp life
Amazon lily
tapirs
white tree frogs
red tomato frogs
piranhas
poison-dart frogs

CENTRAL IDEA GRAPH

RAINFORESTS

WHY RAINFORESTS ARE IMPORTANT

- half the species of plants and animals of the Earth live there
- climate
- medicine from rainforest plants (Quinine – malaria; leaves of the rosy periwinkle – leukaemia)
- food plants (coffee, tea, oranges, rice, maize lemons, avocados, pineapples, bananas)
- useful plants (rubber)

FACTS (general)

- climate: 20-28 degrees wet
- grow in an area around the middle of the Earth (Amazon, Venezuela, Indonesia, Madagascar, Australia, ...)
- home to 50 million people
- 8 000 different plants
- 1/3 of the Earth's oxygen

PEOPLE OF THE RAINFORESTS

- Yanomami (Brazil)
- Penan people (Borneo
- Kuna people (Panama)
- The Gavioes (Brazil)

RAINFOREST ANIMALS

- mountain gorillas (Africa)
- giant otters (Amazon)
- tapir (Latin America, Malaysia)
- lemur (Madagascar)
- quetzal
- humming bird
- snakes
- ⋮

WHY WE ARE DESTROYING THE RAINFORESTS

- sell wood
- use land for cows
- plant coffee, sugar
- dams
- mercury (wash gold)

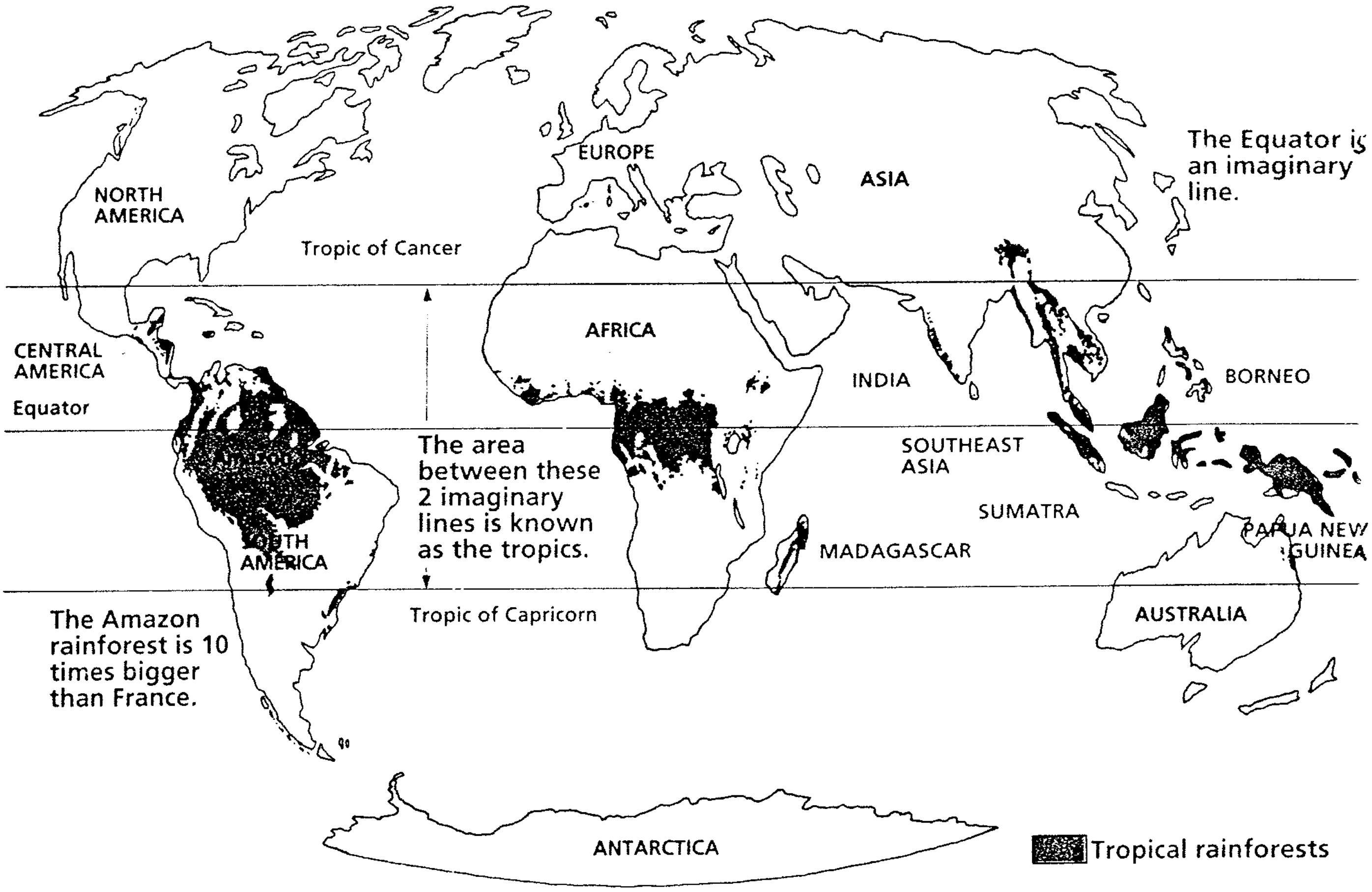
RAINFOREST PLANTS

- mahagony
- Rafflesia
- slipper orchid
- petroleum nut tree
- Victoria water lily
- ⋮

HANDOUTS

Rainforests of the world

Rainforests grow in an area around the middle of the Earth called the tropics where it is always hot and rainy. In most rainforests, it rains nearly every day and the temperature in the day is usually about 30°C (86°F). These hot, wet forests are called tropical rainforests The map below shows where the world's tropical rainforests grow.



Cunningham, Antonia: Rainforest Wildlife (Usborne)