MINUTES OF THE MEETING
EDUCATION SUBCOMMITTEE
50TH LEGISLATURE

February 2, 1987

The meeting of the Education Subcommittee was called to order by Chairman Dennis Nathe at 8:00 a.m. on Monday, February 2, 1987 in the Scott Hart Auditorium.

ROLL CALL: All members were present. Also present were Dori Nielson and Jane Hamman of the Legislative Fiscal Analyst office, Sib Clack of the Office of Budget and Program Planning, and Deb Thompson, Secretary.

MONTANA STATE UNIVERSITY

Representative John Vincent testified concerning the proposed cuts and setbacks experienced by Montana State University. He pointed out that neighboring states spend more money on their universities. He said that high school seniors are planning to go elsewhere to college and Montana is doing the least to keep them here. (152). He stated that a strong University system is any states number one asset in leading strong economic development.

President Tietz (180) distributed the MSU booklet that showed the budget status and impacts. The strategy of the university has been constructive reorganization. The funding base has diversified since the state cannot be depended on for appropriate growth of the institution. He pointed out that the formula did not work. Because of the variance with rules and inconsistent enrollment that changes every legislative session, the university adopts its own independent policy.

President Tietz discussed the increasing costs of higher education and the decline of general funds. He said that indirect cost money has returned $6 dollars for every dollar invested. The MONTS research program is supported by using the indirect cost money. He compared using tuition and 6 mill levy money with fish and game licence fees. He felt there was not much difference in using revenues, which the taxpayers voted for, that should be the university's responsibility to invest and develop. Senator Jacobson (522) asked President Tietz what he had in mind. President Tietz replied to have the freedom to use the money in a lumpsum fashion.

Representative Dick Corne testified in support of MSU. He noted that there was a strong representation from the

university showing the interest and importance of higher education.

President Tietz pointed out that the formula had never been fully funded. He said that 97 percent on support was as good as it had been. (650) The elimination of programs would have to take place in order to meet the proposed budgets, however the core program would be kept.(1-B)

Jim Ish presented the incrementally funded programs in the plant area. He discussed the issues providing incentives for effective management, providing funding for institutional fixed costs, and to provide necessary funding for new space. Due to the financial stress, MSU has looked for new, creative, and innovative ways of managing the institution. They have attempted to use these innovative ways to stretch the budget dollars. In doing so, they have reduced energy costs by negotiating a new natural gas contract with Montana Power. Other projects were mentioned. MSU has requested the ability to reinvest their energy cost savings back into the institution instead of reverting all of the savings to the state. President Tietz explained that there would be no incentive for risk taking. However if rewarded, they would be willing to proceed with innovative projects.

President Tietz discussed the joint funding of the facilities and the new space requirements of the Museum of the Rockies (2-A). He explained that the university is responsible for the personnel at the Museum of the Rockies, but that the operations are supplied by the private sector. He asked that the committee consider new personnel requirements for this new addition to the Museum of the Rockies.

Mr. Ish commented that the physical plant budget is divided by square footage and MSU is currently funded at 76 percent of the average of the other units. He pointed out that the LFA recommendations would reduce this to 60 percent. If this is accepted the total building maintenance would be reduced. He felt that this was a totally unacceptable alternative.

President Tietz discussed the faculty salaries as a high priority. He pointed out that they were 17 percent behind the average salary for similar institutions. He said it was much less expensive to maintain the quality that had been achieved than to try to replace it.

Gary Evans, from the department of health and physical education (069) and chairman of the faculty council, discussed the difficulties experienced on the campus. He said the negative influences of the budget cuts have resulted in

paranoia and a gloom and doom atmosphere. The result of more cuts would be the loss of good faculty.

Dr. Robert Brown, faculty chairman (190), informed the committee that the faculty had brought in about one million dollars in grants. He talked about the research program and graduate program at MSU. He said that more release time to get grants was needed.

Craig Roloff (344) discussed hazardous waste management. The request was for a base adjustment and considered an essential program so that MSU can maintain its compliance with federal and state regulations. He pointed out that this was an investment by the state for future cost containment.

Representative Norm Wallin (446) testified in support of funding for MSU. He said that Montana would not be made prosperous by cutting programs at the state universities. He recommended funding at HB500 levels.

Dr. Mick Hager, director of the Museum of the Rockies, introduced Bea Taylor as the chairman of the museum's capital campaign to raise money for the museum. (Exhibit 2) He said when the museum project was started 8 years ago they had no way of knowing the terrible shape of the economy. He said on the one hand he brings 4.5 million dollars of private support for the museum. The promise of 3 million dollars of additional private support for exhibits, equipment and programs and $900,000 per year in earned income, private support, and grants and contracts. On the other hand, he said $220,000 per year of state support was needed for hiring personnel. He described the programs including the planetarium, dinosaur exhibit, Indian and homestead exhibits, and curriculum materials that have been developed. He pointed out that this museum brought in tourists and that it was a statewide project.

(2-B) Dr. Warren Acton, scientist on one of the last flights of Challenger, testified in support of MSU. He said he worked for Lockhead and had obtained his engineering degree at MSU (Exhibit 3). (171) He pointed out the necessity of sending kids to school.

Lloyd Allen, (269) spoke about his perspective as a citizen, father, and a member of the Montana Science and Technology Alliance. He said he had a business of manufacturing agricultural chemicals. He discussed the various projects the company was involved in worldwide and in the United States. He pointed out that MSU had been helpful and a key ingredient in bringing new diversity to business in Billings.

Charles McLaughlin (366), testified in support of funding for MSU. He spoke about the quality of faculty. He said he had pursued research to find commercial applications of biotechnology. He urged support of the university system because the attitude taken affects the outcome. He pointed out that the university is hardworking and understaffed.

John Morrison, Morrison/Maierle Company in Helena, spoke about concerns that quality be maintained with cutbacks. He received training at MSU in civil engineering and now works on projects around the world (Exhibit 4, 4a).

(3-A) Merv Gunderson, MEPA alumni, discussed the governor's budget cuts. He said the result will be the loss of people and mediocrity (Exhibit 5).

Nancy Grusich, Associated Students of Montana State University, spoke in support of funding for the university (Exhibit 6).

Erica Kantrell (103), senior at Laurel high school, said it was a mistake to do away with one of a kind programs. She pointed out that what the legislature decides will change lives.

Pat Runey, a elementary English major at MSU, said the excellence at the university may be threatened. She has seen overcrowding in classrooms and other signs that are the result of cuts. She recommended maintaining support for MSU.

John Rogers, political science major at MSU, said indecision impacts everybody. He urged support of funding the university.

Julie Delsoglis, major in Indian Arts at MSU, said she gambled her life savings to receive a quality education and urged support of the university.

Jerry Cummings discussed industrial arts in-service training and updating.

Bill Rankin said the budget cuts have serious impacts. A lack of hands-on experience and loss of business and industry result in students suffering. He said quality does not have to be thrown away.

Wade Ayala testified in support of funding for the university (see Exhibit 6).

Owen Letcher discussed the elimination of the school of architechture and the accreditation problems. He presented

student petitions. He said students are worried and their futures are at stake.

Dave Maloney, a parent of an architecture student, spoke about his frustration. He opposed the closing or phasing out of the architecture school. He urged the committee to fund the school at HB500 levels and not allow the cuts to go through.

Dave Davidson (184), a practicing architect for 30 years and a graduate of the school of architecture, strongly advised protecting the school. He said that closing the school of architecture is ill advised and incomprehensible. He pointed out that the school is not duplicated in any part of the system. He protested political gains and double talk of the university president.

Representative Iverson (266) pointed out that the decision to close the school of architecture was professionally made and that a personal attack is unjustified.

Betty Jean Wood, American Association of University Women, discussed the importance of the university system (Exhibit 7).

ADJOURNMENT: The meeting was adjourned at 12:30. The next meeting was announced for 8:00 a.m., February 3, in the SRS Auditorium.

Dennis A. Nathe

DENNIS NATHE, Chairman

dt/2-2

DAILY ROLL CALL

EDUCATION SUB COMMITTEE

50th LEGISLATIVE SESSION -- 1987

Date 2/2/87

NAME	PRESENT	ABSENT	EXCUSED
Rep. Dennis Nathe, Chairman	✓		
Sen. Judy Jacobsen, Vice Ch.	✓		
Sen. Swede Hammond	✓		
Rep. Dennis Iverson	✓		
Sen. Greg Jergeson	✓		
Rep. Ray Peck	✓		

CS-30

faculty derived from the Instruction formula. Instructional support staff are not estimated because actual program FTE are a matter of discretion at each unit and may vary depending on how staff reductions have been made. Vacancy savings were not applied.

ORGANIZED RESEARCH Budget Detail Summary	Actual FY 1986	Budgeted FY 1987	Recommendation FY 1988	 FY 1989
Full Time Equivalent Employees	21.07	14.15	14.15	14.15
Personal Services	547,608.50	547,408	444,549	444,549
Operating Expenses	27,379.71	14,315	54,751	54,751
Equipment	3,221.69	0	31,316	31,316
Total Program Costs	**$578,209.90**	**$561,723**	**$530,616**	**$530,616**
Current Unrestricted Fund	578,209.90	561,723	530,616	530,616
Total Funding Costs	**$578,209.90**	**$561,723**	**$530,616**	**$530,616**
Current Level Services	578,209.90	561,723	530,616	530,616
Total Service Costs	**$578,209.90**	**$561,723**	**$530,616**	**$530,616**

Program Description

This program includes all funds expended for activities specifically organized for research purposes and commissioned either by an agency outside of the institution or separately budgeted by an organizational unit within the institution.

Budget Issues

The amount to be cut from the base of this program is $29,752. The program budget reflects the agency's decision to restructure the research effort in the 1989 biennium by reducing the personal services costs and increasing the operational budget to provide essential equipment and operating support. With the personal services cut of $84,500 and the increases in operations and equipment, the program is still reduced from the FY86 level by approximately $48,000. The FTE remains at the FY87 reduced level because of the differing composition of the personal services costs that will be charged to current unrestricted funding. The current unrestricted appropriation funds only about 8% of the total costs of this program.

PUBLIC SERVICE Budget Detail Summary	Actual FY 1986	Budgeted FY 1987	Recommendation FY 1988	 FY 1989
Full Time Equivalent Employees	.29	.12	.12	.12
Personal Services	5,603.04	7,477	6,048	6,048
Operating Expenses	4,083.43	2,464	4,000	4,000
Equipment	370.00	0	0	0
Total Program Costs	**$10,056.47**	**$9,941**	**$10,048**	**$10,048**
Current Unrestricted Fund	10,056.47	9,941	10,048	10,048
Total Funding Costs	**$10,056.47**	**$9,941**	**$10,048**	**$10,048**
Current Level Services	10,056.47	9,941	10,048	10,048
Total Service Costs	**$10,056.47**	**$9,941**	**$10,048**	**$10,048**

Program Description

The objective of the Public Service Program is to assist the community and state in community planning and development, urban planning, professional certification, natural resources, business, education, agriculture, industry, health and recreation. This program includes all funds budgeted specifically for extension and public service and expended for activities established primarily to provide noninstructional services to groups outside the institution. Such activities include seminars, projects, and support of various organizations established to provide services to the community.

Budget Issues

This program pays a portion of the salary and expenses of the Director of the Cooperative Extension Service. Included in the personal services expenditures in FY87 are the termination payout of sick and annual leave for the retirement of Dr. Carl Hoffman.

The amount cut from the base before positive adjustments were added is $386.

OPERATION & MAINT OF PLANT Budget Detail Summary	Actual FY 1986	Budgeted FY 1987	Recommendation FY 1988	Recommendation FY 1989
Full Time Equivalent Employees	81.68	75.62	75.62	75.62
Personal Services	1,555,577.74	1,685,585	1,539,178	1,539,178
Operating Expenses	3,210,641.71	3,114,788	3,797,628	3,996,712
Equipment	57,665.95	142,640	51,499	51,499
Capital Outlay	19,649.31	185,920	0	0
Debt Service	9,319.94	0	9,319	9,319
Total Program Costs	**$4,852,854.65**	**$5,128,933**	**$5,397,624**	**$5,596,708**
Current Unrestricted Fund	4,852,854.65	5,128,933	5,397,624	5,596,708
Total Funding Costs	**$4,852,854.65**	**$5,128,933**	**$5,397,624**	**$5,596,708**
Current Level Services	4,852,854.65	5,128,933	5,397,624	5,596,708
Total Service Costs	**$4,852,854.65**	**$5,128,933**	**$5,397,624**	**$5,596,708**

Program Description

This program includes all expenditures of current funds for the operation and maintenance of the physical plant, except for amounts charged to auxiliary enterprises and hospitals. It does not include expenditures made from the institutional plant fund accounts. It includes all expenditures for operations established to provide services and maintenance related to campus grounds and facilities, utilities, property insurance, fire protection, and similar items.

Budget Issues

The amount of the base reduction to be achieved in personal services and operations totals $153,225. Personal services was reduced by $42,565 and operations was cut by the remainder. Energy costs savings realized by more efficient use of natural gas on the MSU campus were included in the operational cut.

The reduced base was substantially increased. This results from: increases in fixed costs, such as insurance and bonds, water and sewer rates; allowing 75% of a program transfer from this program into another program in FY86 to be returned to the utilities base ($140,000); and, new space adjustments for the operation of the Controlled Environment Facility in FY87. The amount of the current level new space adjustment that was included in the appropriation for FY87 is $238,414. Base adjustments were included in the Executive recommendation totalling 95% of that amount, or $226,493. This includes an additional $9,000 of personal services costs, $163,000 of utitlities, $20,000 of supplies, $29,000 of maintenance, and $4,500 of contracted services.

Two new space current unrestricted fund modification requests for the 1989 biennium are not included in the Executive recommendation - one for the Museum of the Rockies and the other for the Health and Physical Education building expansion. Since 1979, current unrestricted funds have been appropriated for ongoing maintenance of buildings constructed or remodeled for academic use with other funding sources. The Executive Budget recommends that no current unrestricted funding be budgeted for maintenance of facilities built or renovated with other funding sources. The intent is that the units accept funding responsibility for the on-going maintenance of buildings constructed or renovated with funds other than those approved through the Long Range Building program.

It is recommended that language be added to the General Appropriations Act that a maximum of 50% of the fiscal year energy savings resulting from conservation measures employed by Montana State University directly offset general fund support of this program.

SCHOLARSHIPS & FELLOWSHIPS PGM Budget Detail Summary	Actual FY 1986	Budgeted FY 1987	Recommendation FY 1988	Recommendation FY 1989
Full Time Equivalent Employees	.00	.00	.00	.00
Operating Expenses	896,879.00	954,922	1,023,359	1,023,359
Total Program Costs	**$896,879.00**	**$954,922**	**$1,023,359**	**$1,023,359**
Current Unrestricted Fund	896,879.00	954,922	1,023,359	1,023,359
Total Funding Costs	**$896,879.00**	**$954,922**	**$1,023,359**	**$1,023,359**
Current Level Services	896,879.00	954,922	1,023,359	1,023,359
Total Service Costs	**$896,879.00**	**$954,922**	**$1,023,359**	**$1,023,359**

Program Description

This program applies only to funds given in the form of outright grants and trainee stipends to individuals enrolled in formal course work. Scholarships include: outright grants-in-aid; trainee stipends; tuition and fee waivers; and prizes to undergraduate students. Fellowships include outright grants-in aid and trainee stipends to graduate students, but not funds for which services to the institution must be rendered (e.g., payments for teaching).

Budget Issues

The reason the FY86 expenditure is so much lower for the higher enrollment in that year (10,382 budgeted FYFTE) is because MSU's fee waivers were erroneously recalculated when the Board of Regents raised tuitions prior to the 1985 Legislative Session. Actual FY86 should have been approximately $120 thousand higher.

SUPPORT Budget Detail Summary	Actual FY 1986	Budgeted FY 1987	Recommendation FY 1988	Recommendation FY 1989
Full Time Equivalent Employees	339.26	324.82	329.11	329.11
Personal Services	9,549,166.27	9,396,457	8,028,623	8,028,623
Operating Expenses	2,933,462.20	2,953,735	3,414,912	3,333,312
Equipment	1,040,212.75	1,122,804	250,894	250,894
Capital Outlay	24,708.06	0	0	0
Debt Service	37,491.42	0	0	0
Total Program Costs	**$13,585,040.70**	**$13,472,996**	**$11,694,429**	**$11,612,829**
Current Unrestricted Fund	13,585,040.70	13,472,996	11,694,429	11,612,829
Total Funding Costs	**$13,585,040.70**	**$13,472,996**	**$11,694,429**	**$11,612,829**
Current Level Services	13,585,040.70	13,472,996	11,694,429	11,612,829
Total Service Costs	**$13,585,040.70**	**$13,472,996**	**$11,694,429**	**$11,612,829**

Program Description

The Support Program includes funds for activities designed to support three functions of the institution: academic programs, student services and administrative services.

Academic support - These activities include the retention, preservation and display of materials and the provision of services that directly assist the academic functions of the institution. This category includes libraries, museums and galleries, audio/visual services, academic administration and personnel development, and course and curriculum development.

Student services - These activities include admissions, registrar activities, counseling and career guidance, helping students obtain financial aid, student admissions and records, and supplementary educational services.

Administrative services - These activities include the operational support for the day-to-day functioning of the institution and include executive and fiscal management, general administrative services, logistical services, and community relations.

Budget Issues

The program expenditure level represents 94% of the Support formula using Fall 1986 FYFTE enrollment of 9,573 for both years of the biennium. FTE data for FY88 and FY89 are derived by dividing the formula-generated personal services amount by the average compensation for this composite program as shown in the agency's revised operational plans for FY87 following the 5% cut.

Biennial audit costs of $81,600 are included in FY88.

Agency Summary Budget Detail Summary	Actual FY 1986	Budgeted FY 1987	Recommendation FY 1988	 FY 1989
Full Time Equivalent Employees	265.53	236.43	218.88	218.88
Personal Services	7,361,456.49	7,487,520	6,216,732	6,216,732
Operating Expenses	2,679,516.80	2,271,637	2,371,040	2,350,655
Equipment	237,013.90	478,855	181,148	181,148
Capital Outlay	8,500.00	0	0	0
Total Agency Costs	**$10,286,487.19**	**$10,238,012**	**$8,768,920**	**$8,748,535**
Current Unrestricted Fund	10,286,487.19	10,238,012	8,768,920	8,748,535
Total Funding Costs	**$10,286,487.19**	**$10,238,012**	**$8,768,920**	**$8,748,535**
Current Level Services	10,286,487.19	10,238,012	8,768,920	8,748,535
Total Service Costs	**$10,286,487.19**	**$10,238,012**	**$8,768,920**	**$8,748,535**

Agency Description

Montana College of Mineral Science and Technology was established in 1893 as the Montana School of Mines. From the beginning, special emphasis has been placed upon the four main branches of mineral technology — exploration, production, processing and refining. The faculty of the college and the Montana Bureau of Mines and Geology, a department of the college, also contribute to basic research and innovative approaches to problem solving in the mineral industry.

Bachelor's and Master's programs are offered in engineering science and geological, geophysical, metallurgical, mineral processing, mining and petroleum engineering. A bachelor's program is offered in environmental engineering, and a master's degree is offered in geochemistry (in collaboration with the universities), geology metallurgy and mineral processing. Bachelor's degree programs are also offered in chemistry, mathematics, occupational safety and health, and society and technology.

The college provides services to state government and the citizens of the state by developing, gathering, analyzing, cataloging and disseminating information concerning the location and development of the mineral and energy resources and related resources of the state. This mission is the major responsibility of the Montana Bureau of Mines and Geology. In addition to research activities of individual faculty members, the college is a major participant in the state's magnetohydrodynamics (MHD) research and has been designated one of 20 national Mining and Mineral Resource Research Institutes.

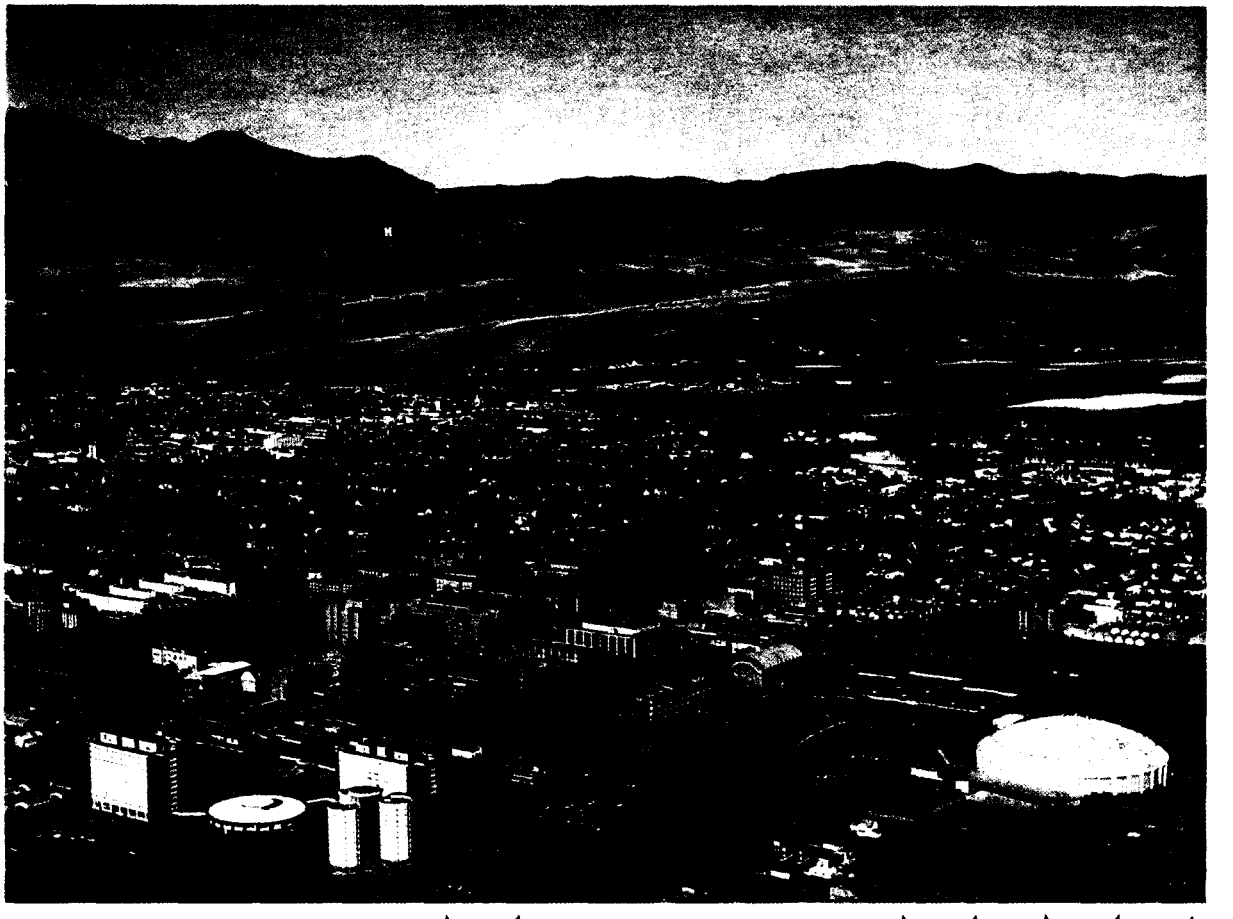
INSTRUCTION Budget Detail Summary	Actual FY 1986	Budgeted FY 1987	Recommendation FY 1988	 FY 1989
Full Time Equivalent Employees	124.10	112.80	87.46	87.46
Personal Services	3,721,665.56	3,794,623	3,025,302	3,025,302
Operating Expenses	500,833.60	353,896	333,309	333,309
Equipment	78,782.31	64,543	54,260	54,260
Total Program Costs	**$4,301,281.47**	**$4,213,062**	**$3,412,871**	**$3,412,871**
Current Unrestricted Fund	4,301,281.47	4,213,062	3,412,871	3,412,871
Total Funding Costs	**$4,301,281.47**	**$4,213,062**	**$3,412,871**	**$3,412,871**
Current Level Services	4,301,281.47	4,213,062	3,412,871	3,412,871
Total Service Costs	**$4,301,281.47**	**$4,213,062**	**$3,412,871**	**$3,412,871**

Program Description

The objective of the Instruction Program is to provide educational activities directed primarily at the production of credits which satisfy the various curricula requirements leading toward a post-secondary degree. The category also includes expenditures for academic administration where the primary assignment is administration (academic deans).

Budget Issues

Instruction is funded at 95% of the formula using Fall 1986 FYFTE enrollments of 1,527 for each year of the 1989 biennium. The FTE listed in FY88 and FY89 are only the budgeted faculty derived from the Instruction formula. Instructional support staff are not estimated because actual program FTE are a matter of discretion at each unit and may vary according to how staff reductions were made. Vacancy savings were not applied.



MONTANA STATE UNIVERSITY

MSU

BOZEMAN, MONTANA 59717

Exhibit 1
2-2-87

MONTANA STATE UNIVERSITY
Bozeman, MT

Presentation to
Education Subcommittee

February 2, 1987

Montana State University
Bozeman, MT

Presentation to the Education Subcommittee
February 2, 1987

Current FY 1986-87 Budget Status

House Bill 500 - Spring 1985	$47,194,557
House Bill 30 - Summer 1986	44,635,258
Reduction (subtotal)	2,559,299
Executive 2.55% Reduction (Nov. 86)	652,390
AES/CES .55% Reduction (Nov. 86)	43,606
Tuition Shortfall (10,211 - 9573)	720,000
Total Reduction	3,975,295*
FY 1986-87 Budget	$ 43,219,262

* Additional reductions of $1,177,122 were necessary to finance the 1986-87 pay plan; total FY 1986-87 reductions equal $5,152,295, or 10.9%.

Board of Regents Approved Request

FY 1987-1988	$48,904,073
FY 1988-1989	$49,005,670

Executive Budget Recommendations

FY 1987-1988	$41,731,554
FY 1988-1989	$41,849,038

Legislative Fiscal Analyst Recommendations**
(Current Level)

FY 1987-1988	$42,194,760
FY 1988-1989	$42,372,163

** Includes $1,235,000 Indirect Cost revenue excluded in the Executive Budget recommendation.

Montana State University
Bozeman, MT

Executive / Legislative Fiscal Analyst Budget Impacts

Program eliminations

a. Veterinary Science

b. Industrial Arts Education

c. Architecture

d. College of Arts and Architecture

e. Departmental designations within the College of Business

f. Business Education

g. Butte Nursing program

h. Great Falls Nursing program

i. Marching Band (state funding)

j. International Education

k. Intercollegiate Athletics (mens and womens skiing, mens wrestling, womens gymnastics)

l. Institutional Research

m. Humanities seminar

Montana State University
Bozeman, MT

Executive / Legislative Fiscal Analyst Budget Impacts

Program reductions/Mergers

a. Merged Theatre Arts and Film and TV into Department of Media and Theatre Arts

b. Transfer administrative responsibility for Arts, Music and Media and Theatre Arts to the current College of Letters and Science

c. Reorganize College of Education

d. Merged Agricultural Engineering with Civil Engineering

e. Merge Speech Communications with English

f. Merge Political Science with Sociology

g. Summer Session

h. Library (tied to other programmatic reductions)

i. Faculty Council

j. Reassign Testing Office to the College of Education

k. Consolidate mens and womens intercollegiate athletics administration

l. Advisory Council

m. Publications and News Service

n. Alumni Affairs

o. Administration

p. Personnel

q. Research Administration

r. Merge administrative programmers with the Computing Center

s. Miscellaneous - institutional memberships, consolidate campus mail services, safety and security, telephone

t. Physical Plant Maintenance

Montana State University
Bozeman, MT

Good News

Academic Success

- MSU continues to be the largest unit in Montana. Enrollments lead the system in 32 counties; in the remaining counties MSU ranks second (Figure 1)

- MSU attracts 54 % of the state's high school honor students and 61 % of its National Merit Scholars, while enrolling only 39% of the state's freshmen

- Implemented core curriculum fall 1986

- First class of 20 Presidential Scholars provided by a private grant to setup a permanent program

- National Education Association calls MSU Writing Center among most advanced in the United States

- Four faculty received Fulbrights; one a Burlington Northern Foundation Faculty Achievement Award; one National Endowment for the Humanities Award; five faculty elected to head their national subject matter associations

- 1986 Accounting seniors had a success rate of 90% on CPA exam; class consistently ranks among the top three universities in the nation

- Two Presidential Management Internships in Washington D.C.

- One National Research Council Resident Research Associateship

- First place National Design Competition, American Institute of Architects

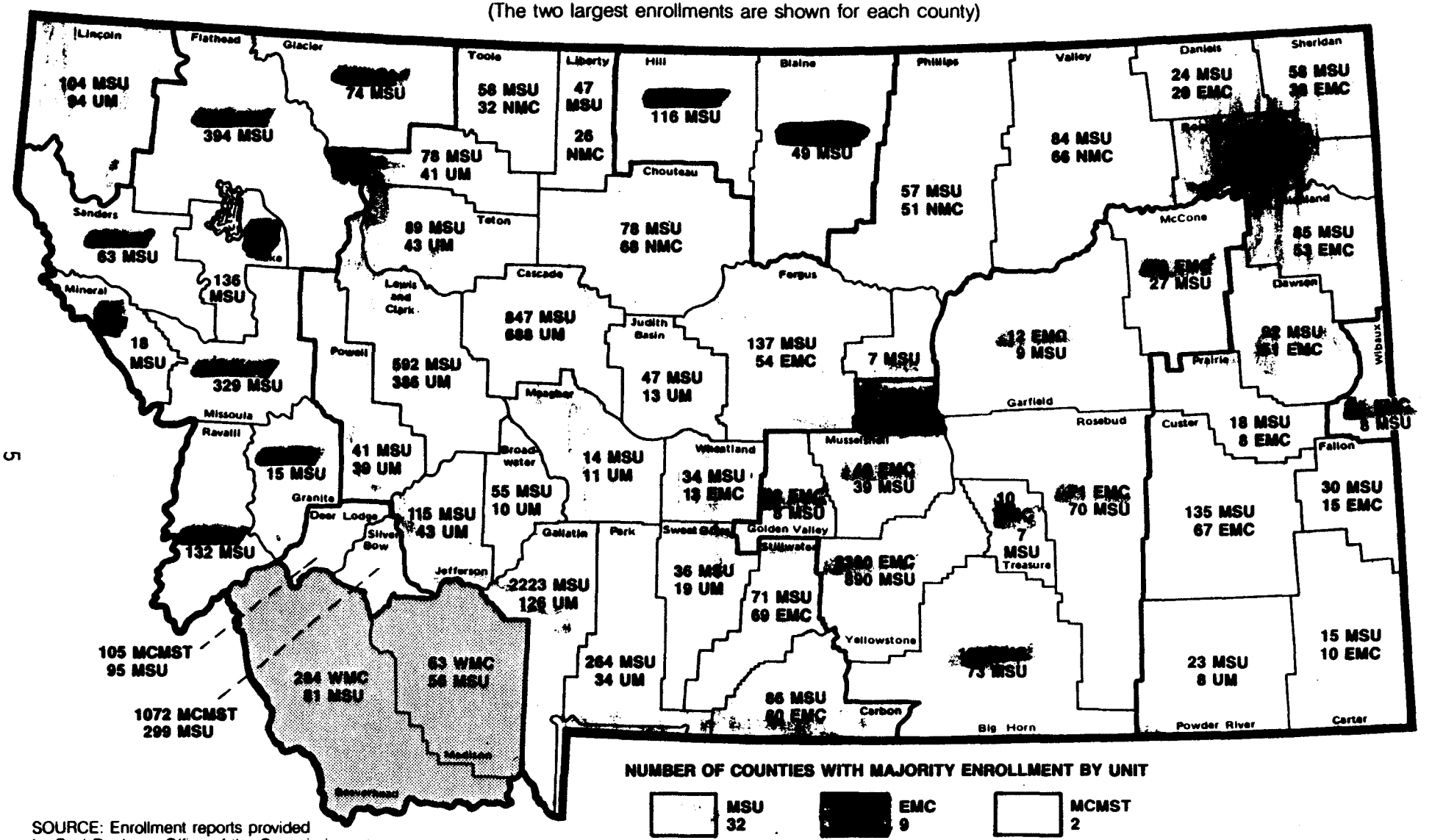
- Outstanding American Society of Animal Science Graduate Student Presentation Award

- National Multiple Sclerosis Society's Public Education Award for best television documentary

- Helene Fuld Nursing Fellowship to attend 1986 International Cancer Congress

- Museum of the Rockies Faculty Member John R. Horner became the first Montanan to receive a prestigious MacArthur Foundation Fellowship to further his dinosaur research

MONTANA UNIVERSITY SYSTEM
AUTUMN 1986 ENROLLMENTS BY COUNTY
(The two largest enrollments are shown for each county)



NUMBER OF COUNTIES WITH MAJORITY ENROLLMENT BY UNIT

MSU	32	EMC	9	MCMST	2
UM	8	WMC	2	NMC	2

SOURCE: Enrollment reports provided
by Paul Dunham, Office of the Commissioner
PUBLISHED BY MSU Office of Administration

FIGURE 1

Montana State University
Bozeman, MT

Good News (continued)

Campus Facilities/Resources

- New Plant Growth Center
- Museum of the Rockies Expansion (privately funded)
- Construction of a backup heating system which allows MSU to save approximately $123,000 per year
- Opened two global microcomputer laboratories funded with student computer fees
- Began first phases of a library automation project which will eventually allow the delivery of MSU library holdings to computer users throughout the University and state
- Designated as a primary computer communication node for the National Science Foundation Computer Network (one of only 20 in the United States and the only one in the Northwest)
- Working with the National Science Foundation and other organizations to locate a supercomputer at MSU
- Major grants to chemistry to allow students to use computer simulations in order to learn to operate sophisticated and costly laboratory equipment

Montana State University
Bozeman, MT

Good News (continued)

Jobs for Montana

- Development of the Advanced Technology Park

- University Technical Assistance Program providing technical engineering and managerial help to manufacturing companies. Purpose is to save jobs or create new jobs for Montana.

- In the past 10 years, seven new Montana firms have grown from research or technology development at Montana State University.

- Additionally, we track 177 Montana firms who use MSU consultants, library, laboratory services, student internships, new technologies and computer services.

- In one survey 62 firms with a combined gross sales of more than $634 million annually rated MSU important or very important to their business activities.

- Last year the $8.3 million that MSU received from out of state sponsors created $23.5 million in new economic activity for the state.

Scientific achievement

- MSU ranks 108th in research excellence among universities in the U.S.; It ranks 68th among the public universities. These rankings include 2800 institutions.

- MSU ranks among the top six universities in the United States in the award of Biotechnology patents.

- MSU does approximately 60 percent of the sponsored research in the Montana University System. The average MSU faculty member generates $17,900 per year in grant money to support his or her creative efforts in behalf of Montana.

Good News (continued)

New Products from Research

- Concentration on Value-added products: bread with improved protein quality; barley components that lower blood cholesterol; and safflower oil that competes favorably with imported olive oils. All have been transferred to private sector for marketing.

- MSU STAT - - statistical software package currently being used in agricultural research throughout the nation

- A white mold fungus that kills knapweed -- now in the developmental phase

- Weather modification or cloud seeding --operating at Bridger Bowl successfully this winter

- New chemical process that allows mining companies to follow ore veins with precision now being tested on campus. Has important implications for the mining in the Stillwater complex.

- Snow research is helping to predict avalanches in the backcountry.

- Asphalt testing for Department of Highways helps create longer-lasting roadbeds

- Institute for Process Analysis draws business and industrial clients from all over North America to Montana for help in solving the productivity problems that result from biofouling. Taxpayers in Helena and Great Falls recently benefited from the Institute's expertise.

Montana State University
Bozeman, MT

Good News (continued)

Research Examples

- Major National Science Foundation grant to the Physics Department to continue the work in materials science.

- Native American biomedical research programs in cooperation with the Tribal Colleges help Native American students find careers in science and technology.

- Dinosaur research at the Museum of the Rockies has put Montana on the tourist and scientific maps. Homestead research at the Museum is preparing Montana for its Centennial.

- Major grants from the Kellogg Foundation to fund research into adult learning and experimental projects for the delivery of course work and workshops to rural areas using telecommunications.

- Major grants to set up Area Health Education Centers to bring continuing education to Montana health professionals.

- More than 317 of MSU's 600 faculty members are involved in outside sponsored research in behalf of institutional goals. MSU currently has more than $38 million of active research projects (Figure 2).

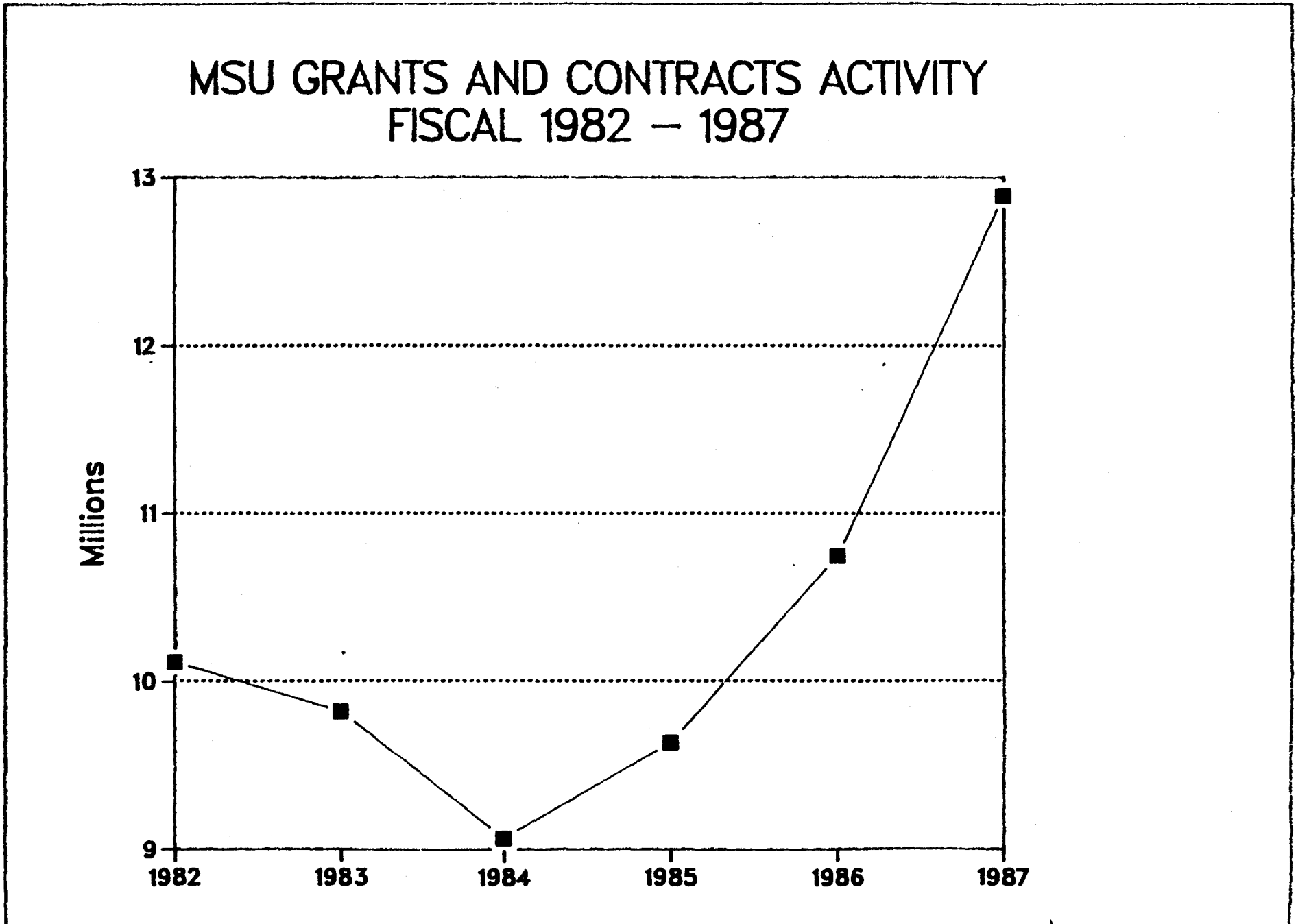

MSU GRANTS AND CONTRACTS ACTIVITY
FISCAL 1982 – 1987
Millions
13
12
11
10
9
1982
1983
1984
1985
1986
1987

FIGURE 2

Montana State University
Bozeman, MT

The Future for MSU

What is MSU's mission for the future?

- Maintain high quality undergraduate and graduate instructional programs in agriculture, engineering, biological and physical sciences and other core humanities programs consistent with MSU's role and scope
- Expand research opportunities especially in the areas of material science and biotechnology
- Assist in the economic recovery of the state by developing and transferring new technology, products and processes to the private sector
- Disseminate MSU's knowledge and expertise throughout the state

How can the Legislature help?

- Increase funding to HB 500 levels (Figure 3)
- Increase management flexibility
  - lump sum appropriations
  - carry-forward appropriations - allows for more orderly staffing adjustments
  - allow for transfers between formula/incremental budgeted programs without penalty
- Provide management incentives
  - reinvestment of savings resulting from management efficiencies (e.g., energy savings, reorganizations, etc.) provides a positive environment for innovation and change
  - encourage externally funded research activity by allowing the campuses to retain 100% of indirect cost reimbursements

FIGURE 3
STATE OF MONTANA GENERAL FUND APPROPRIATIONS

	BIENNIUM % CHG FY 71 FY 87	BIENNIUM % CHG FY 85 FY 87	BIENNIUM FY 71 % SHARE OF TOTAL	BIENNIUM FY 87 % SHARE OF TOTAL
ELECTED OFFICIALS	305.65	(14.84)	1.87	1.70
JUDICIAL	298.59	4.13	1.27	1.13
ADMINISTRATION	227.14	(8.99)	1.46	1.07
AGRICULTURE	253.92	10.03	0.57	0.45
COMMERCE	1,225.90	13.87	0.85	2.53
EDUCATION	209.90	(7.31)	25.36	17.60
FISH, WILDLIFE & PARKS	36.31	(67.99)	0.19	0.06
HEALTH	379.92	6.07	0.98	1.05
INSTITUTIONS	278.70	3.15	20.27	17.19
JUSTICE	138.72	(22.76)	3.71	1.98
BOARD OF CRIME CONTROL	N/A	10.83	0.00	0.13
LABOR & INDUSTRY	-71.08	(40.66)	0.93	0.35
LANDS	2,122.73	11.40	0.42	2.07
LIVESTOCK	94.08	(11.18)	0.39	0.17
MILITARY AFFAIRS	320.13	(9.53)	0.53	0.50
NATURAL RESOURCES	144.22	6.57	2.15	1.18
PUBLIC SVC REGULATION	224.27	(46.57)	0.32	0.23
REVENUE	2,079.24	4.05	1.01	4.94
SOCIAL & REHAB SVCS	964.90	3.75	8.52	20.31
LEGISLATURE	531.61	1.79	1.33	1.88
MISC.	N/A	(13.40)	0.00	1.15
SUBTOTAL (percentages) (all other state agencies)	381.02	(1.22)	72.12	77.69
HIGHER EDUCATION	257.30	(2.95)	27.88	22.31

SOURCE: THE MONTANA TAXPAYER, SEPTEMBER, 1986

NOTES

COLUMN 1: Since the FY 71 biennium, all other state agencies have received an average General Fund increase of 381%. The higher education increase of 257% is only two-thirds of the agencies' average.

COLUMN 2: In the last biennium, higher education's General Fund decrease of 2.95% was 2.4 times greater than the 1.22% average decrease of all other state agencies.

COLUMNS 3&4: Since 1971, higher education's share of the General Fund has declined by 20 percent, from 27.88 to 22.31.

SUMMARY: If these declines are corrected for inflation by using the Consumer Price Index, our spending power, since 1971, has eroded by over 12 percent while the average for all other state agencies has actually increased by over 31 percent.

Montana State University
Bozeman, MT

Formula Funded Programs
(Instruction and Support)

Replace the formula with a base budget plus system

An alternate is a formula budget with the following modifications:

- Utilize a three year rolling enrollment average based on the previous three actual years for formula calculations (Figure 4)
  - consistent with the development of the student/faculty ratio used by both the Executive and Legislative fiscal analysts to develop 1989 biennial recommendations
  - consistent with the enrollment calculations used for the vocational-technical schools
  - cushion enrollment fluctuations allowing for the systematic management of academic and administrative programs
  - consistent with past Legislative practices
- Fund instruction and support programs at 100% of peer averages
  - goal of the legislature when the formula was implemented was to insure that an adequate level of funding was provided each campus
  - campuses compete in national marketplaces for faculty and administrative personnel
  - would raise Montana's Colleges and Universities to the average of the peer institutions
- Provide inflationary increases
  - Inflation factors should reflect the higher education price index rather than the consumer price index used by the analysts

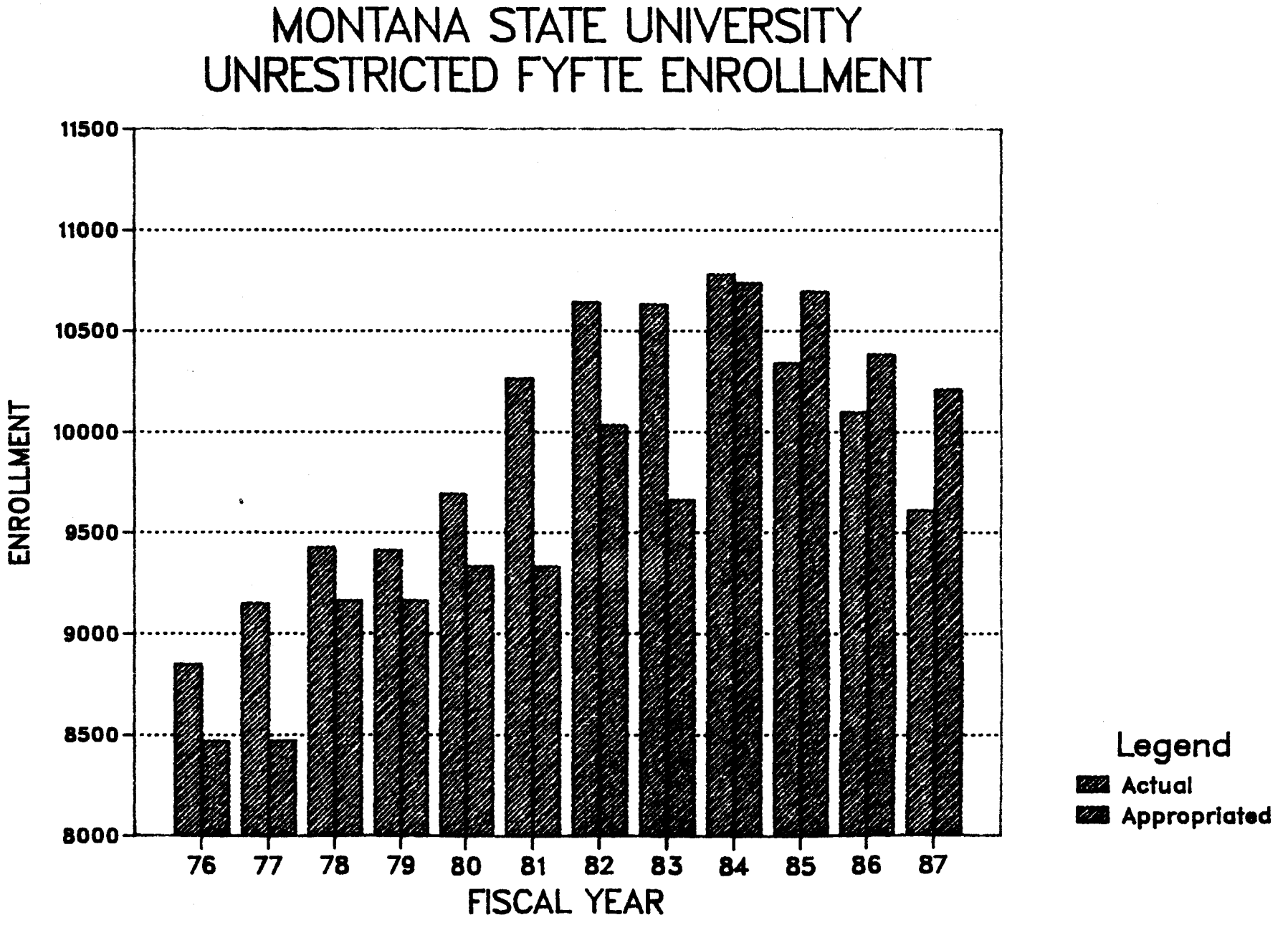

MONTANA STATE UNIVERSITY
UNRESTRICTED FYFTE ENROLLMENT
ENROLLMENT
11500
11000
10500
10000
9500
9000
8500
8000
76
77
78
79
80
81
82
83
84
85
86
87
FISCAL YEAR
Legend
Actual
Appropriated

FIGURE 4

Montana State University
Bozeman, MT

INCREMENTALLY FUNDED PROGRAMS

Physical Plant

Management Decisions

Several adjustments made by the LFA and Executive Budget analysts discourage management initiative and innovation:

1984 Base Adjustment ($229,935)

- LFA recommendation has incorrectly reduced our budget by the amount the 1985 Legislature specifically restored to our FY86 base

Energy Savings ($259,000)

- LFA has overestimated the level of our energy savings and then removed the entire amount from the budget base

Nursing Rent ($22,012)

- OBPP has reduced the budget base by the cost of the facility lease in Butte

Fixed Costs

LFA and/or Executive Budget analyses did not address fixed costs of physical plant operations.

Insurance Costs ($93,954)

- LFA did not recognize a base adjustment necessary to fund all insurance costs as identified by the Tort Claims Division

Water/Sewer Rate Increase ($75,679)

- The City of Bozeman has levied a 93% rate increase for water and a 8% rate increase for sewer, this adjustment has not been recognized by the LFA

Capital ($25,816)

- OBPP has arbitrarily cut 30% of our physical plant capital base

Montana State University
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INCREMENTALLY FUNDED PROGRAMS

Physical Plant (continued)

Plant Growth Center ($94,083)

- State financed the construction of the Plant Growth Center and has should assume the responsibility for maintaining the facility
- Total maintenance funds required to maintain the facility are $318,083
- 1985 Legislature appropriated only 75 percent of amount necessary for a full year operation
- Both OBPP and LFA have now discounted this further, to $224,000

New Space - Health and Physical Education ($24,528)

- MSU requests the funds necessary to operate this academic space

New Space - Museum of the Rockies ($128,758 in FY89)

- This facility was approved by the 1983 Legislature
- This facility enhances our academic program and the region's economic development; an extremely modest investment given the potential for state benefit

Montana State University
Bozeman, MT

Program Modifications

Faculty Salaries ($1,090,418)

- Faculty salaries have eroded in comparison with both regional and national levels
- Creative and innovative faculty improve the quality of both instruction and research
- It is cheaper to maintain educational quality than to rebuild it

Indirect Costs ($935,000)

- Return of indirect costs represents an incentive for increased faculty research efforts
- MSU's grants and contracts activity has increased 18.5% in the past 2 years

Hazardous Waste Management ($67,180)

- MSU has the premier program of the State -- if not the region
- The OBPP budget has ignored this modification; mandated by state statute and federal regulations
  - Montana Hazardous Waste Act of 1981, which adopts Federal laws and regulations
  - Senate Bill 452 of the 1985 Legislative Session which created the Right-to-Know Law
- The LFA alternative of $1,000 per barrel guarantees continually rising costs because it does not fund the innovative and cost effective portion of our program -- our processing/recycling activities

Workload - Museum of the Rockies ($220,980)

- The Museum of the Rockies is an active part of the education, research, and public service mission of MSU
- Increase tourism and retain Montana fossils and other archeological treasures within the state

Montana State University
Bozeman, MT

Revenue Estimates

Tuition and Fees

- LFA estimates include $2 tuition surcharge scheduled to sunset 6-30-87 ($650,000)
- Overestimate of average per student tuition and fee collection ($350,000)

Other Revenue

- LFA estimate exceeds MSU's estimate ($110,000)
- Lower enrollments and federal reductions in student loan programs

Indirect Costs

- Board of Regents and Executive Budget recommendation is that indirect cost be excluded as a revenue source for the unrestricted budget
- LFA estimates based on collections of $1,452,941; State portion is 85% ($1,235,000), University portion is 15% ($217,941)
- The March and June 1986 Special Sessions (HB 18 and HB 30) appropriated $935,000 to the unrestricted budget, the remainder accrues to University designated account

Millage

- LFA estimates appear reasonable given the current state of the Montana economy

Montana State University
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Recommendations:

1) The system request is to abandon the formula and provide a base budget at the HB 500 level ($47,194,557). An alternative would be to utilize a three year rolling enrollment average, to fund MSU at 100% of peer average, and to provide inflationary increases. This approximates HB 500 funding levels within the parameters of the funding formula. Initiate a program to simplify and complete the Montana University funding procedures.

2) Fund the Physical Plant base budget as requested. This level of funding will represent 86 percent of the LFA $/sq.ft. average for the University System ($924,098).

3) Encourage Montana research and economic development by excluding Indirect Costs from University revenue.

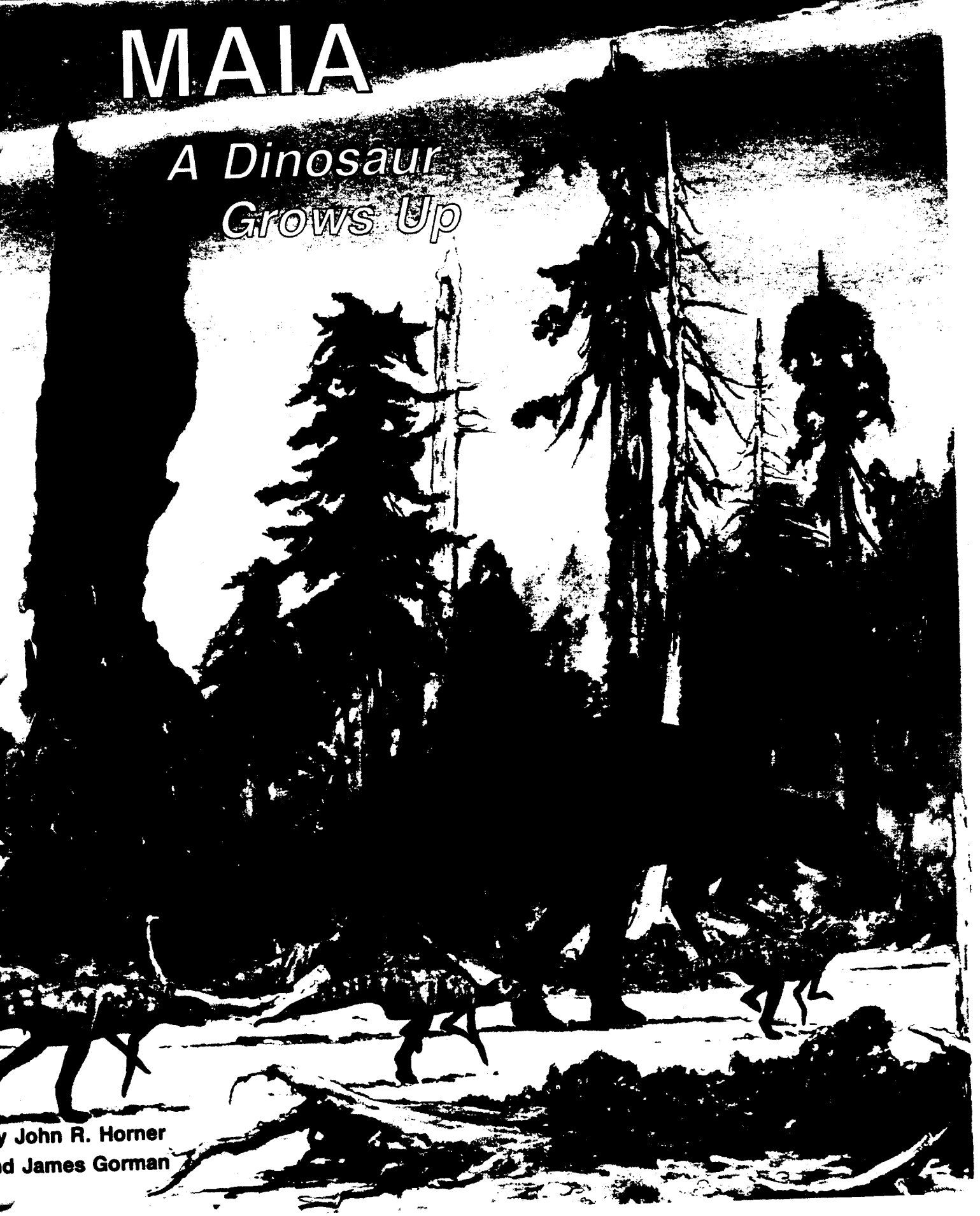
4) Provide full funding for essential System-wide Program Modifications: Faculty Salaries ($1,090,418) and retain 100% of Indirect Costs. Provide full funding for essential MSU Program Modifications: Hazardous Waste Management Program ($67,180), Museum of the Rockies - Workload ($220,980), New Space - Museum ($128,758), and New Space - Health and Physical Education ($24,528).

5) Encourage management efficiencies by permitting retention of realized savings.

6) Increase management flexibility.

MAIA

A Dinosaur Grows Up



y John R. Horner
nd James Gorman

MAIA

A Dinosaur Grows Up

With Best Wishes,
Jack Horner

by
John R. Horner
James Gorman

illustrated by
Doug Henderson

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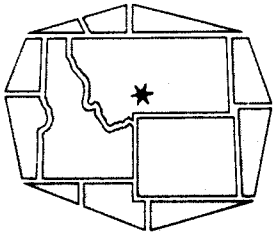
MAIA

A Dinosaur Grows Up



Museum of the Rockies
Montana State University

NOTE TO PARENTS AND TEACHERS:

Dinosaurs were a very special and fascinating group of reptiles that lived as the dominant land animals during 140,000,000 years of earth history. Evidence of their presence on earth comes from their fossilized skeletal remains, footprints, and eggs. Paleontologists, such as myself, are able to make educated guesses as to what these animals looked like, what they ate, what kind of environments they lived in, and how they behaved, by studying their remains and the rocks in which they are found.

The story of Maia is fiction, but it is based on scientific information. We have recently discovered in the state of Montana, fossilized nests, eggs, baby and adult skeletons. As a scientist I formulate ideas or theories based on the kinds of fossil remains that I find. James Gorman, writer, has taken the scientific information and created this story. Doug Henderson, an exceptionally talented artist, has illustrated the story with paintings of scenes that I believe accurately depict our scientific information.

The story was written for young children because of their intense interest in these extinct animals. The study and interest in dinosaurs is often the first introduction to science for children, and unfortunately, in many instances, the information is out-of-date and inaccurate. It is my hope that by giving youngsters our most up to date information, they will continue to find an interest in this as well as other fields of science. I think it is important that they learn with us. I also believe it is important that they realize we do not have all the information, and that in time we may make discoveries which will change some of our ideas. Paleontologists are searching for the truth about dinosaurs. Along the way we may interpret some of the information incorrectly and have to rethink and revise some of our long held theories. That is the way all of science is and, since I don't expect we will ever have all the truths, that is the way it will continue.

John R. Horner

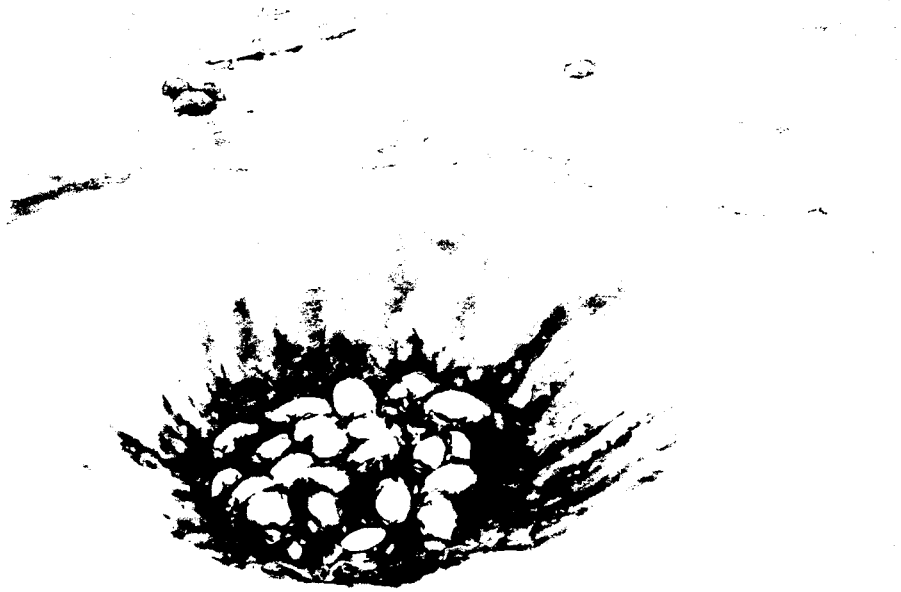
INTRODUCTION

Eighty million years ago Duck-billed dinosaurs lived in what is now Montana. These dinosaurs laid eggs in nests and took care of their young babies, bringing them food. The dinosaur that lived that way is called Maiasaura. It has this name because Maiasaura means "Good Mother Lizard." This book is the story of what life was like for one of these Maiasaurs, whom we will call Maia, who lived and died long before human beings existed.

Out of the Egg

There were no clouds the day that Maia, the duck-billed dinosaur came out of her egg. The sun beat down on the hot dry ground. It shone on the nest of dinosaur eggs. The mother dinosaur had laid her eggs on the ground, and covered them with leaves and twigs. Even under the leaves, inside the eggs, the baby dinosaurs could feel the sun.

Inside Maia's egg, it was dark. Maia felt that she had to stretch. Although the egg was as big as a grapefruit, it was getting too small for Maia. She was a foot and a half long. She was curled up in a tight ball — too tight. She started to squirm, and peep and squeak.



Her mother, who was 30 feet long and weighed two tons, put her head down low over the nest and listened to the sounds. Then she scraped the leaves off the eggs to let the sun shine on them. Suddenly, it was light inside Maia's egg. Maia didn't know what light was, or what the sun was, because she had always been inside the egg, but the light made her want to get out of the egg even more. She began to bang her nose on the shell, jerking her head up and down. On the tip of her nose was something like a tooth. It would wear out and fall off after she had hatched, but for now it was useful. She banged it against the egg with all of her strength. Finally the egg cracked. Then a bigger crack appeared. Soon the whole top came off, and Maia, the baby dinosaur, climbed out into the sun to get her first look at the world.

She was mostly grey, and looked like a big lizard. She had a red mark on both sides of her back that made her look different from her brothers and sisters. She was also different because she was the first one in her nest to break out of the egg.

As soon as Maia tried to move she fell, as all babies do. The first thing she stumbled into was another baby dinosaur, just like herself, coming out of an egg. The next thing she did was step on an egg and break the top. That was all right because another baby was trying to hatch out of that egg. When Maia caved in his roof it just helped him along. Wherever Maia turned, there were more dinosaurs, all her own size, and all just as awkward. Each had just hatched or was right in the middle of hatching. By the end of the day that Maia hatched all the other eggs had hatched too. There were twenty squeaking, tumbling, little baby dinosaurs.

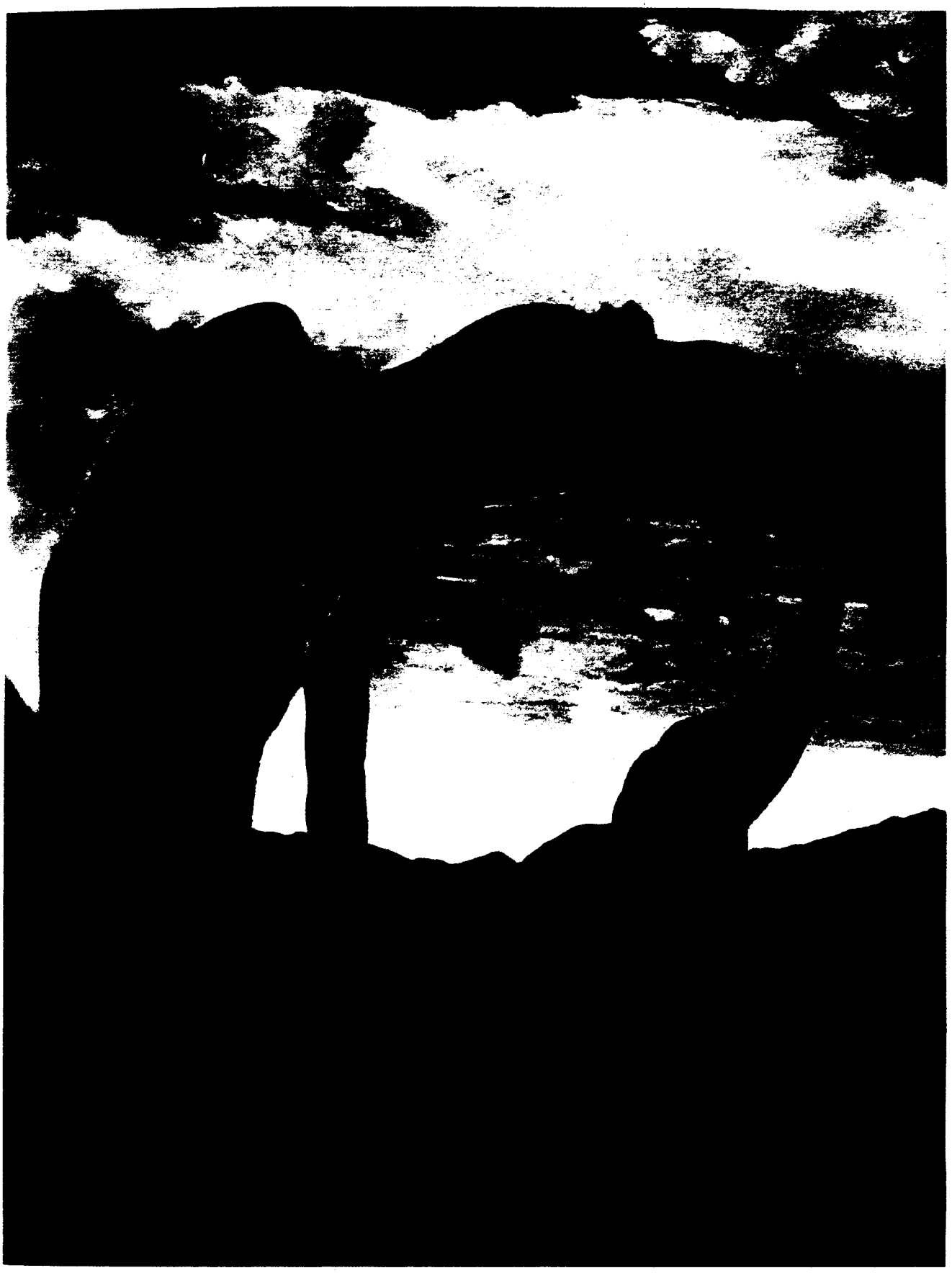
All around their nest were other nests, each on top of a mound of dirt. Each nest was six feet wide and scooped out of the ground so that it was shaped like a salad bowl. There were two hundred nests, all filled with baby dinosaurs. The mother dinosaurs who had laid the eggs stayed by the nests or went to the banks of the nearby stream to gather food. There were berry bushes by the stream, and in it fish waved their tails, alligators hunted, and turtles on logs lay basking in the sun.

Maia didn't know anything about the other dinosaurs or the turtles and the stream. She couldn't even see over the edge of her nest. All she knew was that she was hungry. Of course, she didn't know exactly what being hungry was, since she had never needed to eat before. She just felt so empty that she squeaked. It was such a loud squeak that it knocked her down. She was surprised that noises that loud could come out of her. She felt hungry again, so she stood up and squeaked again. All the other babies were doing it too. Soon, it seemed like the most natural thing to do, to squeak and squeak, and make a noise that would send a human mother running out the door.

That isn't what Maia's mother did. She came right over to the nest. Maia looked up and saw an enormous reddish brown creature with a mouth that looked like a duck's bill. The bill was full of berries. As Maia watched and squeaked, her mother bent down and dropped the berries from her mouth. Maia wasn't frightened. She was a dinosaur, so her mother looked just right, big and red, with a mouth full of berries.

Maia smelled her mother's mouth, and then she sniffed the berries. They smelled so good she grabbed them in her mouth and started crunching them between her teeth. They tasted so good she grabbed more and ate them. So did the other babies. The only thing on Maia's mind was berries. She pushed and shoved on her unsteady legs like a greedy puppy, trying to eat every berry in the nest.

Soon the feeling that made her squeak stopped. She wasn't hungry anymore. She stopped eating, and she stopped squeaking. The sun was beating down on her, and it was hot. She closed her eyes and went to sleep. It had been a very big day.



A Scary Day

The next day, and the day after that went along in the same way. Maia never left the nest. She and her brothers and sisters slept, and squeaked, and ate. Their mother brought them nuts and berries from the bushes that grew on the banks of the nearby stream. Maia's father sometimes came by the nest too. He prowled around the nesting ground and smelled all the babies, even the ones that weren't his own.

As the days passed, Maia grew. She was the quickest of the babies in her nest, and she was usually first to snatch a berry when it fell in the nest. Some of her brothers and sisters were bigger than she was and some were smaller. One had bumpy skin on it's nose. Another had a crooked leg and a crooked tail. He had come out of the egg that way. Maia was the only one with red patches on her back.

One day, as Maia was about to fall asleep in the sun, she heard screaming and honking from the adult dinosaurs. She was big enough now to see over the edge of the nest and she saw a pack of red dinosaurs the size of wolves running through the nesting ground. They were *Troödon.* Maia squeaked and screamed with the other babies as the pack ran by. The adult duckbills were chasing them. Maia saw that one *Troödon* had a baby from another nest in his mouth.

The duckbills became quiet as soon as the pack of *Troödon* ran from the nesting ground. Life went back to normal. Maia slept. She woke up. She tried to push Crooked Leg out of the nest. He pushed back hard because even with his bad leg he was strong and both of them tumbled over the other babies.

A few days later the pack of *Troödon* came again. When the screaming and honking started, Maia and her brothers and sisters squeaked for help, but their mother was off in the woods. The *Troödon* pack ran right at Maia's nest. One *Troödon* stopped at the edge. He had a long, toothy head at the end of a snake-like neck. He scared Maia so much she wanted to run as fast as she could, but she was afraid to leave the nest. It was the only place that she knew. The babies were afraid to run, and they were afraid to stay, so they just squeaked and crowded toward the far end of the nest. The *Troödon* moved fast. His head shot forward, and his jaws snapped shut on the biggest duckbill in the nest. He snatched him up and ran away to eat him.

The screaming soon died down, because the *Troödon* pack had escaped. Maia and her brothers and sisters calmed down. They forgot right away about the baby that was gone. That wasn't because they were mean or cruel. It's just that they were dinosaurs. Someone in the herd would always be getting caught and killed by meat eaters. They would always forget and get on with what they were doing. But there was one thing Maia did not forget. That was the *Troödon.* As long as she lived, whenever she saw a *Troödon,* she would know he was an enemy.

Leaving the Nest

The packs of *Troödon* came often to the nesting ground. Other babies were snatched from Maia's nest, and two became sick and died. One rolled over the edge and down the side just as an adult was walking by, and was crushed. Maia survived because she was quick and lucky. Most of her time she spent eating, and growing.

Maia grew so fast she almost split her skin. By the time she was only five months old, she was three feet long. Her brothers and sisters had grown too. They were changing color. Their bills were wider and longer. They were all so big that they could barely fit in the nest. When their mother brought food, they all jumped and rushed for the berries. It was so crowded, Maia was always finding some other baby's foot or tail in her mouth. One day, she was in such a hurry eating berries that she didn't notice that she had caught Crooked Leg's tail in her mouth. She bit down hard, and he screeched and whirled around and tumbled her over the edge of the nest. Of course, she scrambled right back. Even though the nest was crowded, none of the babies wanted to be out of it. They wanted to stay in the nest, and eat.

They got what they wanted, until the day their mother didn't bring any food. This set off an awful racket of squeaking and honking among Maia and her brothers and sisters. All day passed and a night too, and still no food came. The next morning Maia's mother showed her head over the edge of the nest. All the young dinosaurs expected berries. Instead they got a surprise. Their mother stuck her bill in the nest and tumbled three babies out of the nest with one push. Maia got caught the second time. She came rolling down the outside of the nest, did a somersault, and landed on her head. By the time she could sit up straight and look around her, all the other young dinosaurs were out of the nest, sitting on the ground.

Maia had plenty of room now, but it was scary. Her mother looked bigger than ever. There were adults almost ten times Maia's size, all around her. There was no comfortable nest to protect her. As if all this weren't scary enough, her mother started walking away. All the young dinosaurs squeaked and honked but Maia's mother kept on walking. Soon she would be gone and the young dinosaurs would be all alone, and outside the nest. Nothing like this had ever happened before, and Maia wasn't going to let it happen now.

She didn't wait an extra second. She got up on her feet and ran after her mother. Crooked Le was next, and their brothers and sisters followed. They all kept squeaking and honking with all their might. Maia's mother walked right out of the nesting ground with her whole family chasin after her. She walked and walked, and Maia and the other youngsters got more and more hungry. Maia's mother didn't stop until they came to some round, tall bushes full of the plump berrie Maia had eaten in the nest. She had never seen them on a bush before. She had never seen a bush.

Maia's mother dropped her head to the bush. She closed her mouth on the branches, and sh pulled back, ripping off leaves, twigs, berries and all. Maia and the others crowded around their mother, waiting to be fed. To their surprise, she ate all the berries herself. While Maia and th other young dinosaurs honked and squeaked around her, she crushed the berries and leaves with her teeth, and swallowed them. Only a drop or two of berry juice ran down from her chin an fell on the babies at her feet.

That was too much for Maia. She was too hungry to wait. She went over to the bush and bit on a low branch. She only got a few berries the first time, so she tried again. The next time sh got more. Her brothers and sisters did the same. All of them bit and tore the berry bushes. Maia was very happy to feed on the bushes. Once she was full, she waded into the nearby stream, an drank. Being in the water was like getting wet in the rain, except there was so much water. She came out of the stream feeling ready for a nap, but just as she was about to lie down on a war rock that she had picked out, her mother walked off again. The rest of the family had to follow and Maia had to run to keep up.

A Long Trip

Maia lived with her family near the mountains for a year. She learned to live outside the nest. Maia's mother taught her and her brothers and sisters all the good things to eat. Maia learned where the berry bushes were, where the streams were, and where the best places to sleep were. She also learned to stay away from the meat-eating dinosaurs who were always trying to catch duckbills.

By the time the year was over, Maia was fifteen feet long and weighed 750 pounds. She was not a baby any longer, nor were her brothers and sisters. Only eight of them had survived. Luckily, Crooked Leg was one of them. As he had grown, his leg had gotten stronger. He was never quite as quick as Maia, but he was quick enough.

At the end of the year, all the families began to come together. Each day more dinosaurs came to join the great herd. Soon there were hundreds of dinosaurs. They raised clouds of dust when they walked. They stripped trees bare when they ate. They made a noise like an earthquake when they ran. Maia had never seen so many dinosaurs. Once the herd was together, it began a journey. Slowly, each day, the herd moved east. Each day, bit by bit, the land grew greener. Maia didn't know what was happening, but the older dinosaurs did. The herd was leaving the nesting place, where the ground was dry and good for nests. They were traveling down to the lowlands, on the edge of a great sea.

It took a month for the herd to travel 100 miles. When they stopped, they were in a place that was like nothing Maia had ever seen. There were trees and bushes and water all around. Different kinds of green plants grew everywhere that Maia looked. No brown dust from the dry earth got in Maia's nose. The land was wet and warm and full of good things to eat. Maia learned to eat new kinds of trees, and bushes, and water plants. Sometimes she waded into ponds and swamps and pulled up lush green plants with her bill.

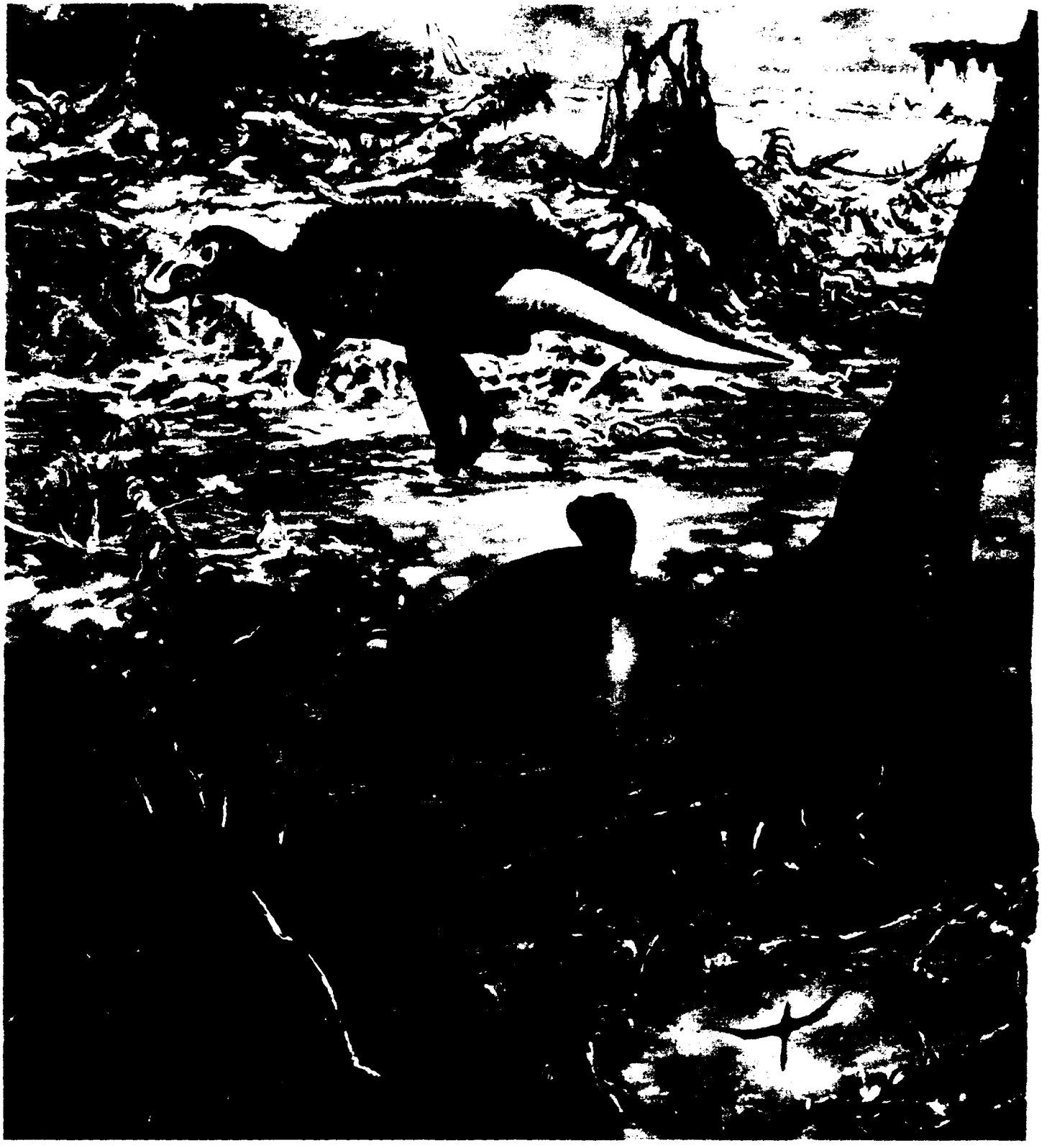
There were many dinosaurs that Maia had never seen before. There were ankylosaurs, with clubs on their tails. There were dinosaurs like monoclonius, with long horns and hard skin. There were other duckbills. There were lots of meat- eaters. The biggest and most dangerous was called *Albertosaurus.* The albertosaurs were 30 feet long, with huge heads and long, sharp teeth.

Maia knew that she should always be watching for meat-eaters, but there was so much new, delicious food that sometimes she forgot. One day she was chewing the leaves of a soft swamp tree. It was so good that she wasn't thinking about anything else. As she bent for a low branch she heard a loud sucking noise behind her. She turned and saw an albertosaur lifting his foot from the mud. He began to charge, and as he came close she could hear his teeth click. Maia was as scared as she had been when the *Troödons* attacked her nest, but now she was bigger, and faster, and she knew she had to get away.

She turned and ran, splashing in the muddy pond. She was lighter than the albertosaur and the mud did not slow her down as much as it did him. He leaped forward to catch her, but instead of closing his jaws on her leg, he fell face first into the muddy water. Maia kept running, as fast as she could, and she didn't stop until she found her family. She had learned an old lesson once again. No matter how quick she was, she still had to be careful. She could never have a relaxed meal. Like all the other duckbills who wanted to stay alive, while she was eating, she had to look around her every half-minute to make sure that no other dinosaur was about to eat her.

Good Mother Maia

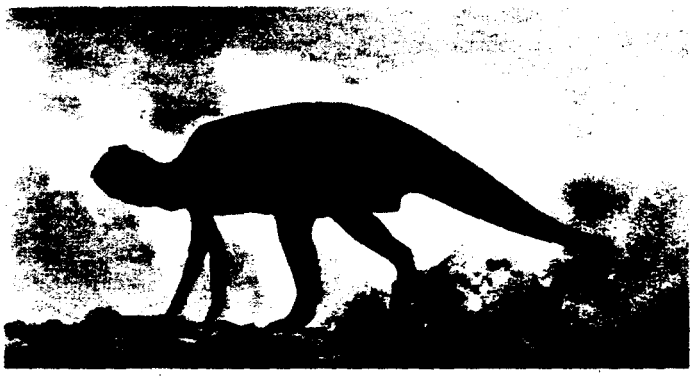
In the lowlands Maia grew big, and she grew up. One year, the dinosaurs in Maia's her gathered to go back to the nesting ground, near the mountains. They were going to make nests and raise babies. Maia's mother went with the herd. Maia and her brothers and sisters were a too young to make their own nests so they stayed in the lowlands.



Maia began to spend all of her time with Crooked Leg and two of her sisters. Together they explored the land near the sea. Once they went right to the shore. Maia waded in the ocean and started to drink. The water was so salty it almost made her sick, so they traveled back to the ponds and swamps they knew.

A second time the herd gathered to go back to the nesting ground, but still Maia didn't go. She was still too young to be a mother. When the herd gathered for the third time, Maia felt different. She was now 30 feet long and weighed two tons. She was as big as her mother had been. It was time for her to be a mother too.

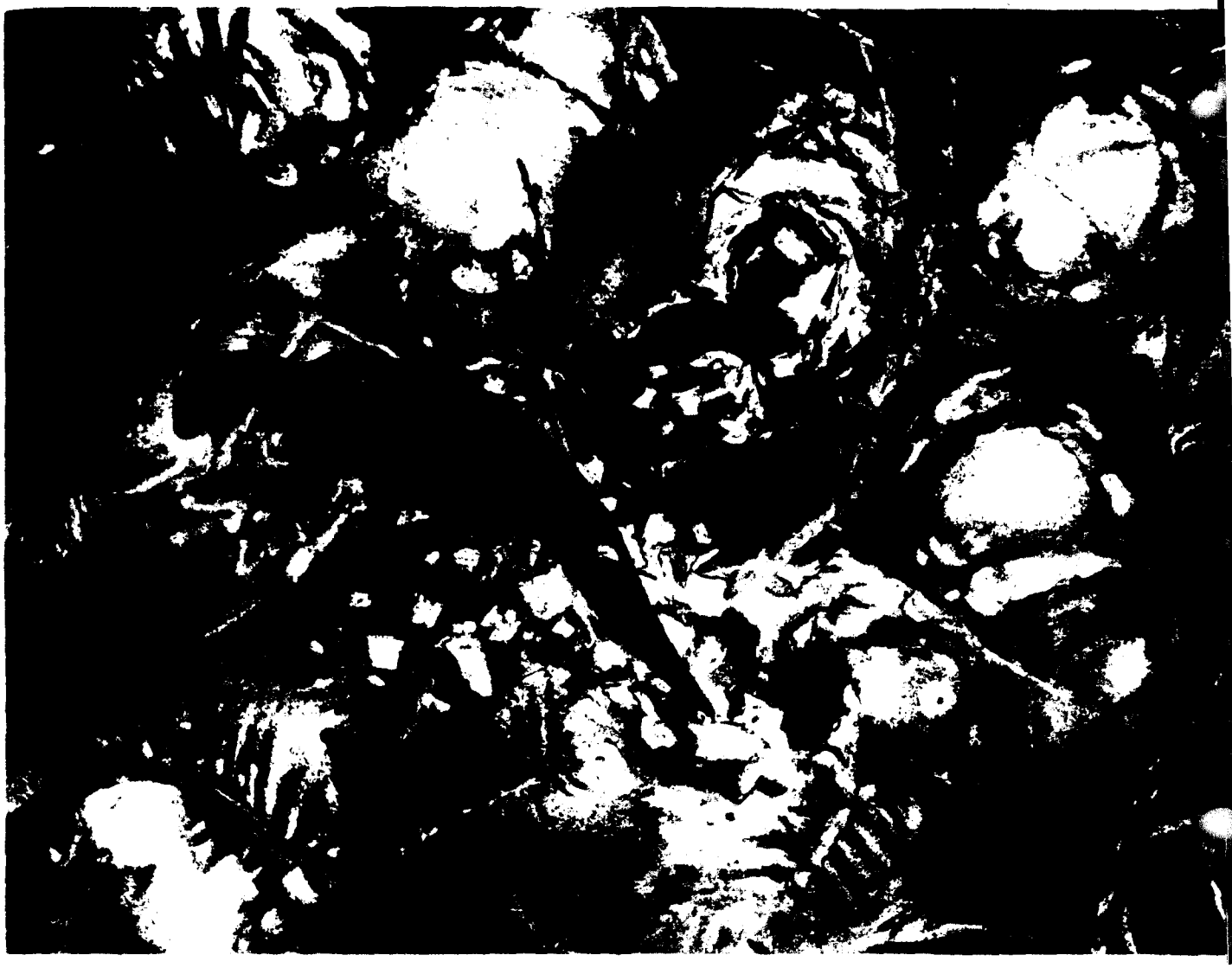
She joined the herd with Crooked Leg and her sisters. They all made the trip to the nesting ground. In a month they came to the high dry land near the mountains. Here Maia could lay her eggs safely. In the wet ground in the lowlands the eggs would have rotted and never hatched. When they reached the nesting ground Maia picked a good spot. With her powerful hind legs she scratched up dirt to make a mound. Then, with her short arms she hollowed it out at the top. The nest was six feet across, and shaped like a salad bowl.



Maia waited near her nest for a mate. Several male duckbills, with long fringes down their backs would come and parade around her. They would bellow at each other, and show off their fringes so that they looked big and strong. Maia picked the one with the best fringe. He was her mate. The other males had to find other females. Maia laid 25 eggs. She poked each of them into the ground and covered them with leaves to keep them warm. Even though Maia had never made a nest before, she knew what to do. And she did it all herself. Her mate was busy eating, or prowling around the nesting ground. Maia was very careful about her eggs. She watched over them and tried to keep lizards away from them. She was not alone as she waited for them to hatch. Hundreds of other female dinosaurs, just like her, did exactly the same thing.

One day, near her nest, Maia heard a faint squeak, almost like a bird chirping, but there were no birds nearby. She lowered her head just above the nest, just as her mother had once done. She listened carefully, and she heard one squeak, and then another, from babies still inside their eggs. She pulled the leaves and twigs off the eggs, and let the sun shine on them.

She waited, and after a while, one egg cracked. Next the top was pushed off, and a tiny nose poked up out of the egg. Out came the baby dinosaur into the sunlight. It stumbled, like all babies do. Then another came out, and another, and the squeaking got louder. Maia went off to the berry bushes where she had first learned to gather her own food. With one bite she swept a basketfull of berries into her mouth. She carried them back and dumped them in the nest, and watched all the little babies fall over each other to get them.



Every day Maia went to gather berries. Every day she kept away from the big meat eaters. Every day she saw packs of *Troödon* running through the nesting ground and sometimes she chased them. One day just as Maia returned from the berry bushes, she saw a *Troödon* at the edge of her own nest. She dropped the berries from her mouth and they rolled all over the ground. She let out a great blast of noise that made every dinosaur on the nesting ground look at her. Even the *Troödon* stopped, and looked up. That was a mistake. By the time he saw Maia running toward him, it was too late for him to escape, and he was too small to fight Maia.

Maia stepped right on the *Troödon*. She had powerful legs and she caught him with one foot before he could move. Her foot crushed him. She kept bringing her foot down on the *Troödon* until his body rolled down the side of the nest in a limp heap. Maia waited, and watched the *Troödon* to see if he would move. She sniffed him. When she was sure he was dead she pushed him further away from the nest. She got more berries and gave them to the nestlings who squeaked with delight.

Maia was happy too, because she had saved her babies. There would be other dangers, later on, but not right now. Maia had done her job well, even though it was her first nest. Maia was a good mother dinosaur.

GLOSSARY

Albertosaurus. (al-ber-tuh-sawr-us): A meat-eating dinosaur that stood about 8 feet tall at the hips, and weighed about 3 tons. Its remains have been found in Alberta Canada, Montana, and Wyoming. Albertosaurs were related to the tyrannosaurs.

Dinosaur. (di-no-sawr): A common name meaning "terrible lizard" that was given to two groups of extinct reptiles (ornithischians and saurischians) that were closely related to birds.

Duck-billed dinosaur. A common name given to the hadrosaurs because of their duck-like beaks. There are many varieties of duck-billed dinosaurs, some of which have hollow crests on the tops of their heads. Duck-billed dinosaurs, or hadrosaurs have been found all over the world, and were problably the most common kind of dinosaur. Duck-bills ate plants and were probably the only reptiles to ever live that chewed their food.

Maiasaura. (mah-ee-uh-sawr-uh): A kind of duck-billed dinosaur, or hadrosaur found in western Montana. *Maiasaura* means good mother lizard. Newly hatched maiasaurs were only 14 inches long and weighed about 1½ lbs. Full grown they were about 30 feet in length and weighed around 3 tons.

Monoclonius. (mon-o-clone-ee-us): A horned dinosaur found in Montana and Alberta. Full grown it was about 20 feet long and weighed around 2½ tons. *Monoclonius,* like all of the horned dinosaurs ate plants.

Paleontologist. (pail-e-on-tall-o-jist): A scientist that studies the remains of extinct or fossil life. A vertebrate paleontologist studies fossil animals that have skeletons, whereas an invertebrate paleontolgist studies animals that lack bones. A scientist that studies fossil plants is called a paleobotanist or a botanical paleontologist.

"The Sea". In this story Maia and her brothers and sisters go to a sea which existed in the Middle of North America. The sea connected the Gulf of Mexico with the Arctic Ocean during the time of dinosaurs. This warm sea has been named The Western Interior Cretaceous Seaway.

Troödon. (true-o-don): A small meat-eating dinosaur that probably grew no larger than 6 feet in length. The teeth of *Troödon* are found commonly in the areas where the maiasaurs nested, suggesting that they may have eaten baby dinosaurs.

John Horner is curator of paleontology at the Museum of the Rockies in Bozeman, Montana, and adjunct professor of geology at Montana State University, of which the museum is a part. Horner is the only scientist to discover an extensive dinosaur nesting ground, and the only scientist to have found the fossilized skeletons of baby dinosaurs in their nests. His work had led him to the conclusion that dinosaurs fed and protected their young over a period of several months, while the babies stayed in the nest.

His discoveries have been covered in *The New York Times,* in *Discover Magazine,* and in numerous other publications. The children's television science program *3-2-1 Contact* featured Horner's work in a program aired in 1984. Also in late 1983 Hugh Downs of NBC's *20-20* did an in depth interview with Horner which aired in January of 1984. Horner himself has published reports of his work in *Nature,* the prestigious British scientific journal, and *Scientific American.*

James Gorman has written about science for a number of national magazines. He does a monthly column for *Discover* magazine, and he is the author of "First Aid for Hypochondriacs," a book of nonsensical medical advice. He lives outside of New York City with his wife and two daughters.

Doug Henderson is a painter and lithographer who lives in Montana and has worked with Horner on several projects. He has done illustrations for many publications.

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Rewriting the History of DINOSAURS

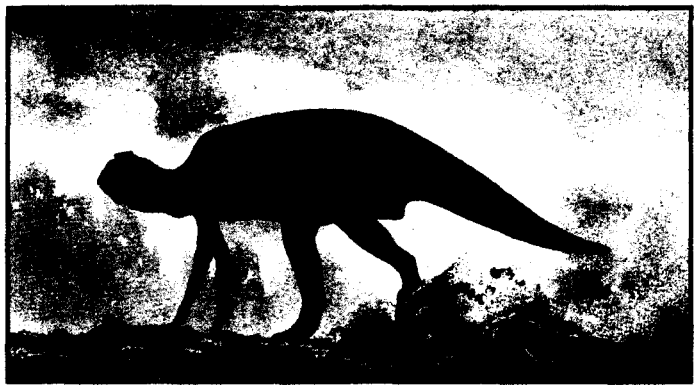
In Montana, paleontologist Jack Horner is unearthing some startling ideas about the behavior of these prehistoric creatures

By Virginia Morell
Illustrations by Doug Henderson

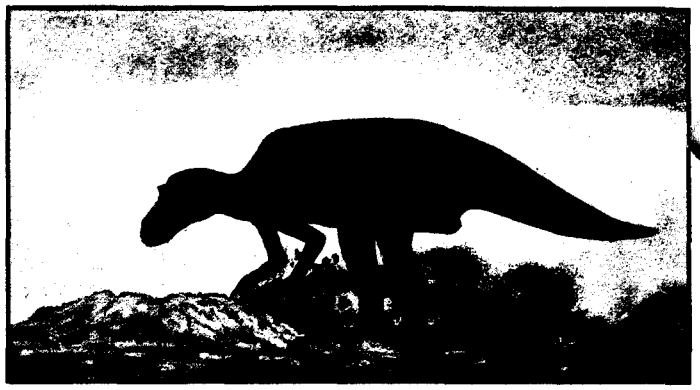
With discoveries like this baby dinosaur skull, scientist Horner has not only uncovered new species but entire rookeries of animals that may have developed the first social behaviors on Earth. He believes that the dinosaurs were warm-blooded.

A 30-foot-long female duck-billed dinosaur leads her offspring on a foraging expedition in this artist's conception of how the eastern Montana region appeared some 80 million years ago (below). Horner called the creatures Maiasaurs.

At a nest site, a female builds a mound



. . . and hollows out a six-foot-wide nest.



"WHAT I'D LIKE to find about now is a big, ugly bone," says Jack Horner as he hunches forward on hands and knees, brushing at the dirt with a small paintbrush. Several fossilized bones, one and two feet in length, lay partially exposed on the hillside, but he dismisses them. "Small potatoes."

Horner grabs an icepick and jabs at the hillside, loosening the soil, then scoops away the crumbly earth. A small end of a bone pokes out. Horner exchanges the icepick for the brush and sweeps away the dirt. "Well," he sighs, "another rib." He frowns, squirts a stream of shellac over the exposed bone and sits back cross-legged, studying the rough hole he and his co-workers have gouged in this eastern Montana hill.

"We need the head or the pelvis so we can tell if what we've got here is a new dinosaur," he says. "I'm pretty sure it's new. No one has ever looked for dinosaurs from this time period [80 million years ago] in North America before, so everything should be new and we'll have to think up new names." Horner smiles at the idea. "New dinosaurs," he adds with an even bigger grin, "are neat."

In the past eight years, Jack Horner, curator of paleontology at Montana State University's Museum of the Rockies in Bozeman, has not only uncovered several new species, but entire rookeries of dinosaurs, complete with nests, eggs and babies—discoveries that have yielded startling new ideas about these giant creatures and how they lived.

Contrary to the long-standing image of dinosaurs as dim-witted reptiles, Horner pictures them as tremendously successful animals which evolved the first social behaviors on Earth. He also believes that they were warm-blooded; in the past, most scientists thought that dinosaurs, as reptiles, were cold-blooded. "Horner's discoveries are spectacular," observes William Clemens, a professor of paleontology at the University of California at Berkeley. "It's the first time we've been able to see how members of dinosaur species developed, and Horner's interpretations have certainly influenced my thinking about how they lived."

Unlike many other researchers, Horner does not particularly care why the creatures disappeared. "I want to know what living dinosaurs were like, what they ate, how they cared for their young," he says. "They were around for 140 million years, and we've been here for only four million. So you'd think we might try to understand why they were so successful, instead of concentrating on why they became extinct."

A tall, lanky Montanan, Horner has spent most of his 40 years seeking answers to that question. He found his first dinosaur bone on his father's ranch when he was eight. He labeled the bone "104-A," put it in a box with other fossils, and decided to find more. Since then, he has scoured eroded gullies and weathered hillsides across the state.

Dinosaurs are so unlike us," says Horner, digging at the earth once more with his icepick. "We don't even know for sure which are herbivores and which are carnivores." His two student assistants, Phil Peterson and Pat Murphy, work with pickaxe and shovel above him, taking off the top of the hill. By midmorning, the trio has uncovered two additional ribs and part of a shoulder blade. Horner decides to visit the site of his most famous discoveries: Egg Mountain.

He climbs into his pickup and heads east on a gravel road that cuts across a golden prairie. Ahead of him lies the Sawtooth Range of the Rocky Mountains. Horner found his childhood dinosaur bone in this same region, but once he began collecting fossils professionally, he devoted most of his time to exploring exposures closer to the Canadian border. Geologically, that area is known as the Judith River formation and many of the finest and largest dinosaur skeletons come from its beds. Horner, however, was not interested in just another adult dinosaur skeleton; he wanted to understand the dinosaurs' complete life cycle. To do this, he needed babies and juveniles.

"Most people thought dinosaurs grew up at random, sort of like lizards do," explains Horner. "Then, in the 1970s, a few scientists, like Robert Bakker of the University of Colorado, began to make some wild guesses—good wild guesses—about dinosaur ecology and behavior." In two revolutionary papers published in the British science journal, *Nature,* Bakker argued that the dinosaurs were not as reptilian as most experts believed. Instead, he suggested that they were warm-blooded creatures which must have lived far differently from any lizards we know. "One group still lives," he wrote. "We call them birds." About that time, with some luck, Horner found Egg Mountain.

In 1978, he and his colleague, Bob Makela, stopped in at a rock shop in Bynum, Montana, to examine a large bone the owner, Marion Brandvold, had found. She showed them the bone, and then pulled out a coffee can with some pencil-thin bones in it. "I took one look at those and just gasped," recalls Horner. "They were what I'd been searching for years for—baby dinosaur bones." Brandvold took Horner and Makela to the site where she found the bones, and within a week they had uncovered a nest filled with the fossilized skeletons of 15 babies—the first dinosaur nestlings *ever* discovered.

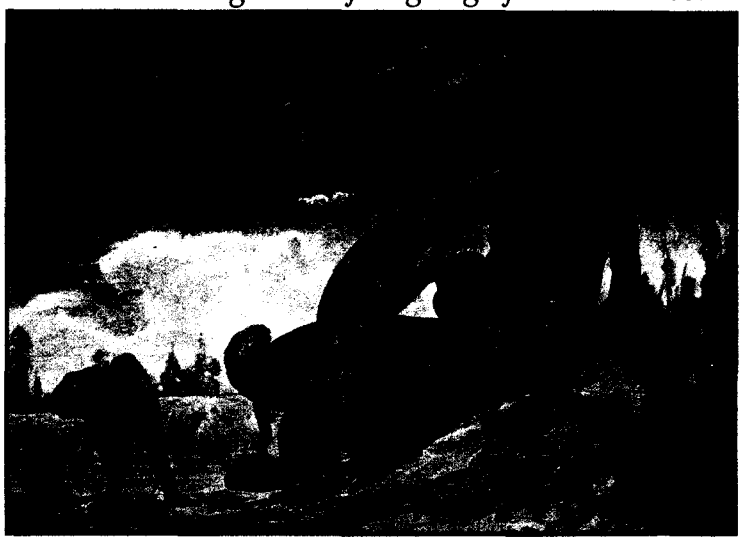
After mating, she lays 20 or so eggs

. . . and keeps them warm with leaves.

Carrying a billful of berries, the two-ton mother attends diligently to her young.

ILLUSTRATIONS FROM *MAIA, A DINOSAUR GROWS UP*, COURTESY OF THE MUSEUM OF THE ROCKIES, MONTANA STATE UNIVERSITY, BOZEMAN, MONTANA

A mother nudges her fledglings from the nest.



The next summer, while following the surveying markers left on a nearby knoll by a seismic crew, a member of Horner's team stumbled onto a dense patch of fossils. Horner moved his team to this knoll, and over the next several seasons, from 1979 to 1984, they dug and jackhammered nearly 500 dinosaur eggs out of its hard mudstone. In tribute, Horner gave the small prairie hill its whimsical name—Egg Mountain.

The eggs had been laid by Hypsilophodonts, swift running vegetarians about ten feet in length. Nearby, Horner also found the nests and eggs of some members of the Hadrosauridae, or duckbilled dinosaur, family. Thirty feet from nose to tail, Hadrosaurs were semierect vegetarians with rounded backs, short arms and ducklike faces. Near Egg Mountain, the duckbills laid their eggs in nests, three feet wide and six feet deep, which they scooped out of the mud and grasses. In some of the nests, Horner uncovered complete clutches, 20 to 25 eggs, neatly arranged in cylindrical patterns; in others, he found the bones of more nestlings. There were also skeletons of juveniles and adults. It was exactly what Horner had been searching for: the first evidence of dinosaur family life.

It was immediately clear that these dinosaurs had not lived like any reptiles we know today, but, as Bakker had suggested, were more like birds. Most reptiles lay their eggs, then abandon them, leaving the young to fend for themselves. The duckbilled dinosaurs, however, covered their eggs with grasses and reeds, then lingered alongside their nests until the warmth of the sun hatched the eggs. "The Hadrosaurs nested in great colonies, like penguins or gulls do, and cared for their young—and that is one of the main reasons, I think, that dinosaurs were so successful," says Horner. "They practiced parental care."

Horner parks the pickup at the bottom of the 50-foot rise that is Egg Mountain, and begins working his way up. At the top, he stops to survey the surrounding land and fossil deposits. To his eye, the eroded hillside speaks of a world when there was no prairie, and the Sawtooth Mountains were young and newly formed, and only 200 miles from a vast inland sea.

Based on an accumulation of fossil evidence from the site, Horner pictures Egg Mountain in the day of the Hadrosaurs as an island in a shallow lake upcountry from that sea. Every year, thousands of duckbills migrated there from the coastal plains to nest in a great, honking, teeming colony. Swift, carnivorous dinosaurs, called Troodons, traveled the upland country in packs, and huge Pterosaurs soared among the trees. The lake's waters may have afforded some safety to the waddling, defenseless duckbills. There was also the safety of numbers.

During the years of uncovering what had transpired at Egg Mountain, Horner found evidence of other birdlike behaviors. For example, birds which nest in colonies space their nests at wing-tip to wing-tip distances. In like manner, 30-foot Hadrosaurs set their nests 30 feet apart. Further, the nests of birds which raise altricial young (babies that are helpless) are always littered with eggshell fragments.

"Baby duckbills lived in their nests and their parents brought them food—berries and grasses," notes Horner. "We know this from looking at the wear marks on the babies' teeth. They had been feeding for some time when something happened to their parents. They were too young to fend for themselves, so they died. But it is very, very rare to find dead babies in the nest because they were well taken care of."

Struck by the duckbills' maternal instincts, Horner named them *Maiasaura peeblesorum*—the latter after the Peebles family which owns the land where he made his finds; *Maiasaura* for "good mother lizard."

"We've found 50 bones per square meter around Egg Mountain," says Horner, "which suggests that in this deposit there are approximately 10,000 dinosaurs. I think they were killed in a volcanic eruption, then transported a mile in a mudflow."

Rising lake waters sometimes washed over the nesting colonies, engulfing the eggs so suddenly that even the beginnings of life were preserved; inside 22 of the eggs, Horner found duckbill embryos. He now had the complete life cycle, from eggs to embryos to nestlings, juveniles and adults. It convinced him that Bakker is very likely right on another point: dinosaurs were warm-blooded. A baby Hadrosaur is 13 inches long at birth and grows to 30 feet, notes Horner. "If you're born little and have a long ways to grow," he says, "it is selectively advantageous to grow fast—and to do that, you have to be warm-blooded."

Horner thinks he can prove this through a study of the growth rate of the dinosaurs' bones. Such a study, however, requires more than one or two species of dinosaurs. Horner needs more dinosaurs, and once again the complete range, from babies to adults.

It is late afternoon by the time Horner returns to the dig. Phil and Pat have pushed the excavation further into the hillside. Thick ribs and several vertebrae lie nearby. Pat looks up from his section and says, "We've got the pelvis." Horner flashes a smile and bends down to look. He studies the bone structure for a moment, then stands up.

"Well, boys," he beams. "Looks like we've got ourselves a new dinosaur. It's another Hadrosaur, but it's a new species." Horner picks up an icepick and brush, and sits down cross-legged in the dirt. "Now let's find its head." ■

California writer Virginia Morell traveled to Egg Mountain with Jack Horner last summer. Montana artist Doug Henderson worked with the paleontologist to conceptualize the dinosaurs in his illustrations.

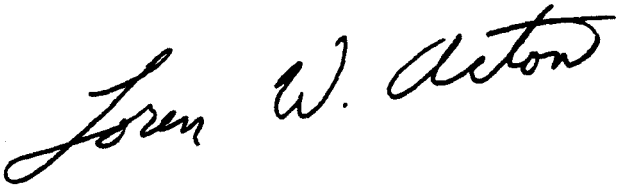
Each year, thousands of duckbills migrated from the plains to higher nesting grounds.

LOCKHEED HORIZONS

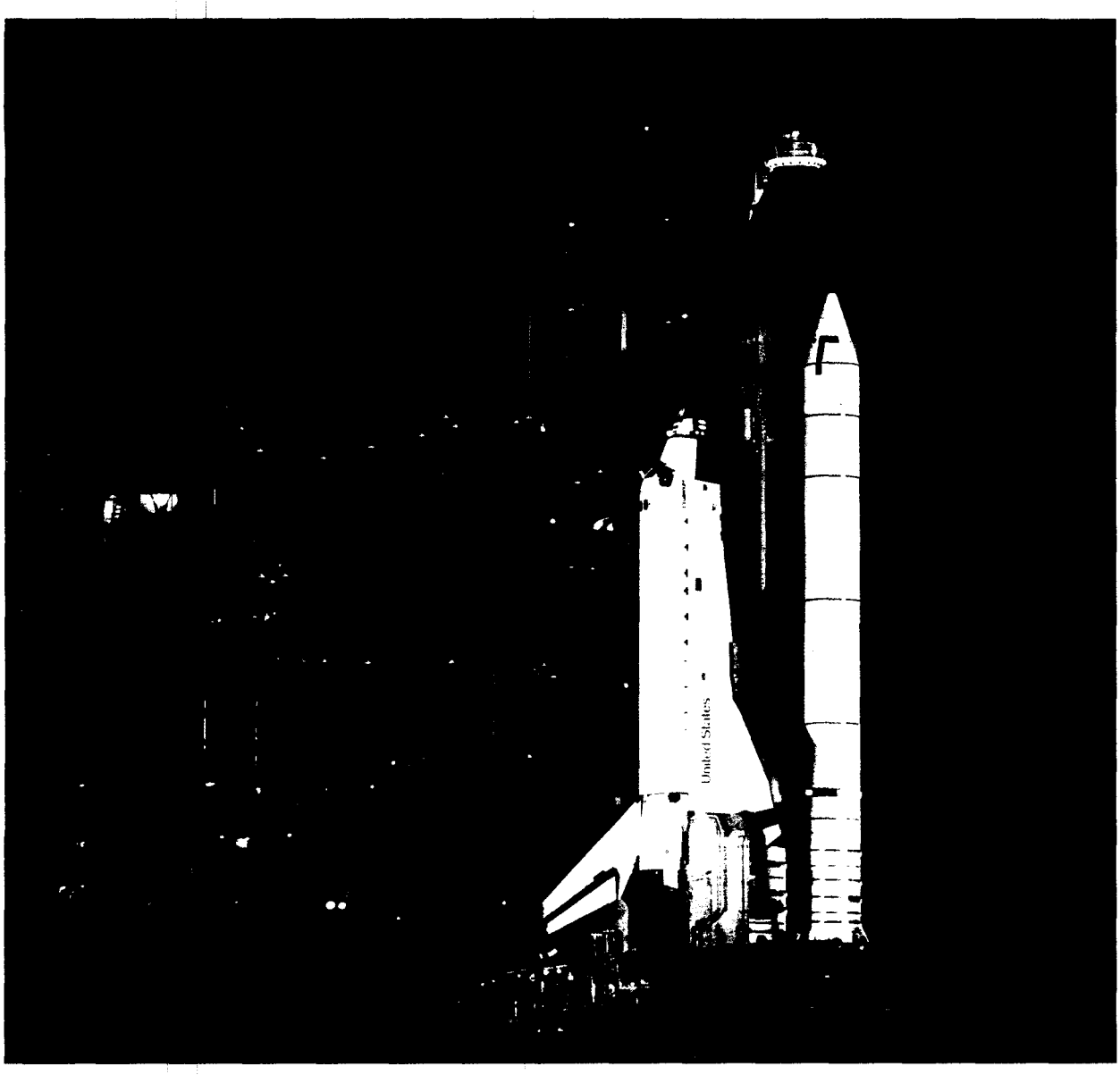
Reprint

From the first tentative expeditions of primitive men and women to our present journeys into space, new knowledge has sprung forth from the adventure of exploring the unknown. These discoveries and insights have helped to banish the myths and fears that accompany those things we do not understand. This legacy of knowledge and the will to continue to pursue the adventure of science and its application to the betterment and enrichment of peaceful life on earth is a costly, precious and treasured gift we can give to our children. It is they and theirs who soon must assume our stewardship of this lovely and fruitful planet. It is we who must see to it that their task is not made impossible because of our timidity, penuriousness or short-sighted self interest.

This account of the Spacelab 2 mission is dedicated to those individuals who have accepted the challenge to explore the unknown and have laid down their lives in this worthy quest.



Loren W. Acton
October 1986



Challenger *poised for a 3-million-mile voyage of scientific exploration on the night before launch.*

SOLAR SCIENCE FROM ON HIGH—THE FLIGHT OF SPACELAB 2

Loren W. Acton
Senior Staff Scientist, Palo Alto Research Laboratory

with

Stephen J. Pehanich
Public Information Coordinator, Public Relations Organization

Lockheed Missiles & Space Company

We may mount from this dull Earth, and viewing from on high, consider whether nature has laid out all her cost and finery upon this small speck of Dirt. So, like Travellers into other distant countries, we shall be better able to judge what's done at home, know how to make a true estimate of, and set its own value upon every thing.

Christian Huygens
The Celestial Worlds Discovered
c. 1690

In the late 17th century, Huygens could have never imagined how prophetic his words would be. Reaching beyond the earth to explore other worlds, civilization has become more human than ever before. The pursuit of knowledge, which separates the human mind and spirit from the beast, is seldom better epitomized than in the exploration of space.

The flight of Spacelab 2, the nineteenth space shuttle mission, was a complex scientific mission to study biological, astronomical, and solar phenomena above the earth's atmosphere. From this high vantage point, data were collected that will be used by scientists around the world, endeavoring to understand the earth and the universe a little better.

Selection Process and Training

Spacelab 2 was planned as an operational and engineering test of the Spacelab system. A diverse number of disciplines were represented on the flight, but as the Investigators Working Group discussed their nominations for payload specialist it gradually became apparent that the four solar experiments would benefit most from having trained specialists on board as observers and operators.

This resulted in the nomination of ten candidates, from which NASA selected four finalists in 1978. They were Dr. John-David Bartoe, from the Naval Research Laboratory; Dr. Dianne Prinz, also from NRL; Dr. George Simon, of the Air Force Geophysics Laboratory; and me.

The seven years between the selection and flight were spent meeting with investigators to learn about their experiments, and working with these scientists and NASA to perfect mission plans. The crew had to understand not only the operation but also the principles behind the investigations.

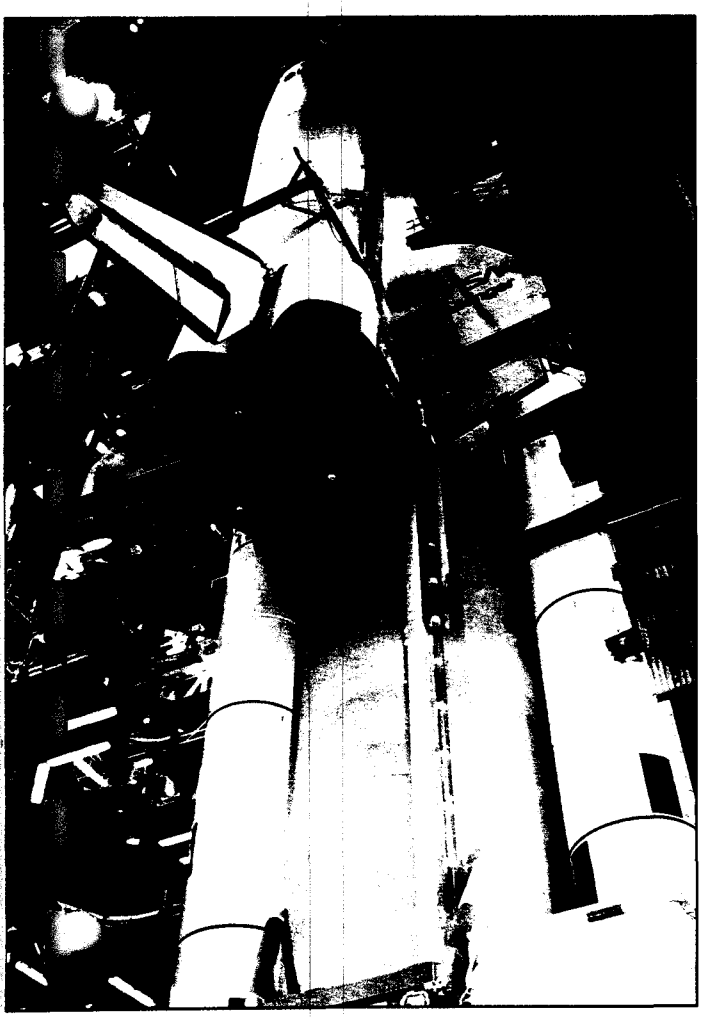
The Spacelab system presents a unique opportunity to modify and enhance experiments in real-time while on orbit. By working closely with the principal investigators on the ground, it is possible both before and during the mission to suggest improvements and modifications. In terms of the scientific return from a mission, this allows Spacelab crews to take maximum advantage of the time in space and to better deal with any unexpected developments.

Payload specialists also receive rudimentary astronaut training which includes such skills as how to move in zero gravity, the operation of the galley, emergency egress procedures, and management of the notorious shuttle lavatory facility. Conducted at the Johnson Space Center, this training constitutes only about two months.

The final year of training was full time at the Marshall, Johnson, and Kennedy Space Flight Centers. Our work centered on mission simulations and procedure verification. Before that time, training was about quarter time, allowing the payload specialists to continue work at their home laboratories.

Launch on the Space Shuttle

After waiting seven years for our mission to begin, the final week before launch was a joy. Contrary to expectations of last-minute hectic preparations, once the crew is placed in isolation the time passes like a mini-vacation. There is time to visit with family, review procedures, relax, and



The space shuttle orbiter Challenger *is lowered into place for mating with the external tank.*

Rollout of Challenger *past the work platforms in the Vehicle Assembly Building at Kennedy Space Center.*

reflect. (Family members and NASA personnel who come in contact with crew members the last seven days before a mission are given physical examinations to insure no colds or viruses are spread so close to flight.)

The countdown leading to our first launch attempt on 12 July 1985 was flawless. One of the more interesting experiences was the arrival at Pad 39A on the day of launch. Unlike earlier in the week, when hordes of personnel were preparing the vehicle and payload, the pad area was deserted. There were no guards, no technicians—just the crew and three personnel to strap them in and seal the hatch. If you are one of the last crew members to enter the vehicle there is plenty of opportunity to thoroughly inspect *Challenger*, an impressive space chariot by any standards.

When the first launch attempt was aborted three seconds before liftoff, after the main engines had already started, the first reaction was, "Will we ever get this thing off?" After years of delay it seemed the mission would never get started. The only recompense was to greet family and friends at the "post-launch" parties in Cocoa Beach.

In the case of Spacelab 2, the seventeen-day delay had both advantages and disadvantages. The greatest benefit was to the super-fluid liquid-helium experiment, which had experienced a breakdown on the launch pad, but was repaired on time for the rescheduled launch. Also, one of the more promising developments was the appearance of an active region on the sun's surface. This gave an opportunity for the complement of four outstanding solar telescopes to examine a wider variety of solar features. A setback was delivered to the infra-red telescope, because the new launch date was near full moon and would limit the area of sky it would be able to survey.

Our next launch attempt was made on 29 July 1985. Technical delays of more than 1½ hours and threats from

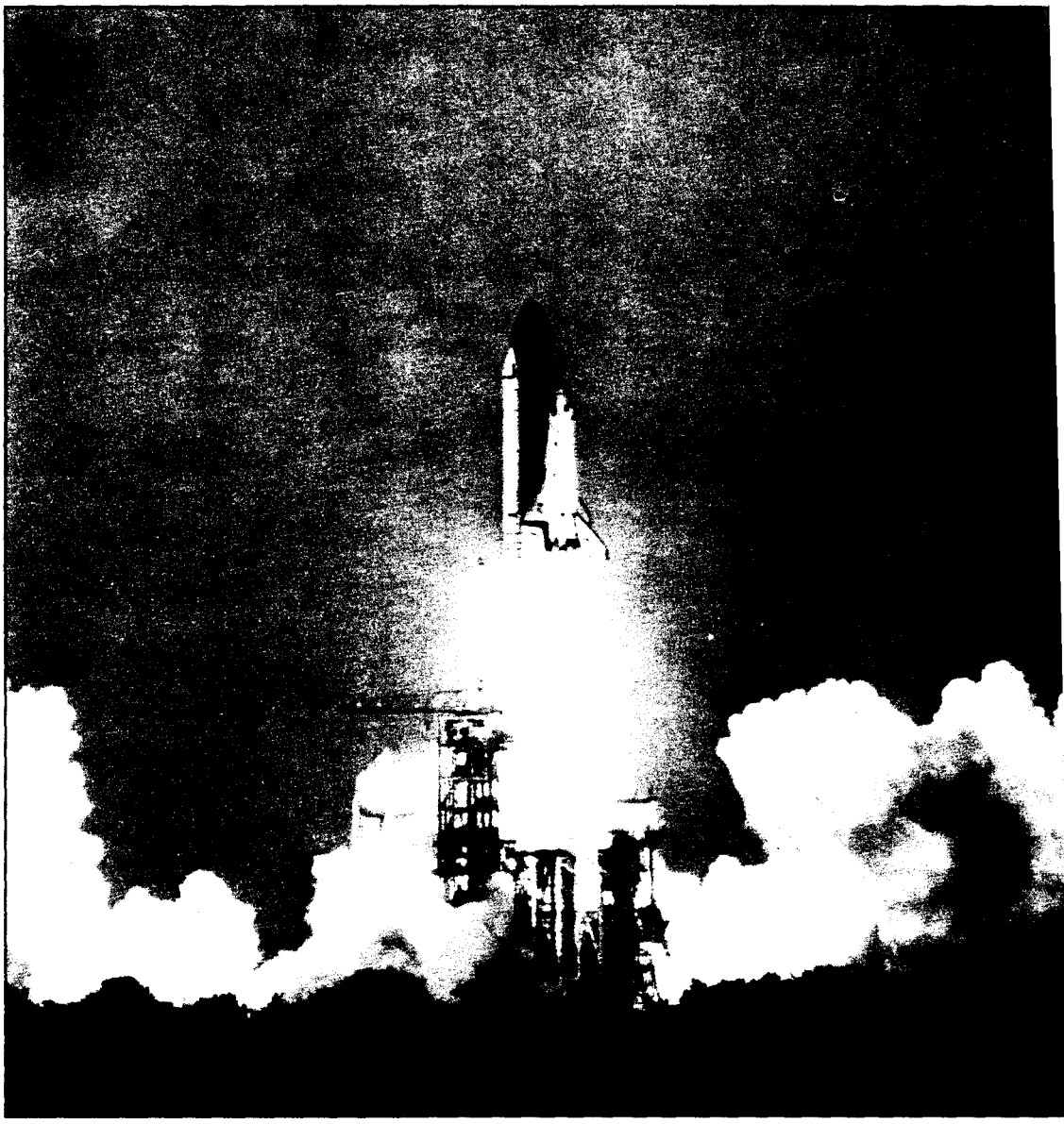


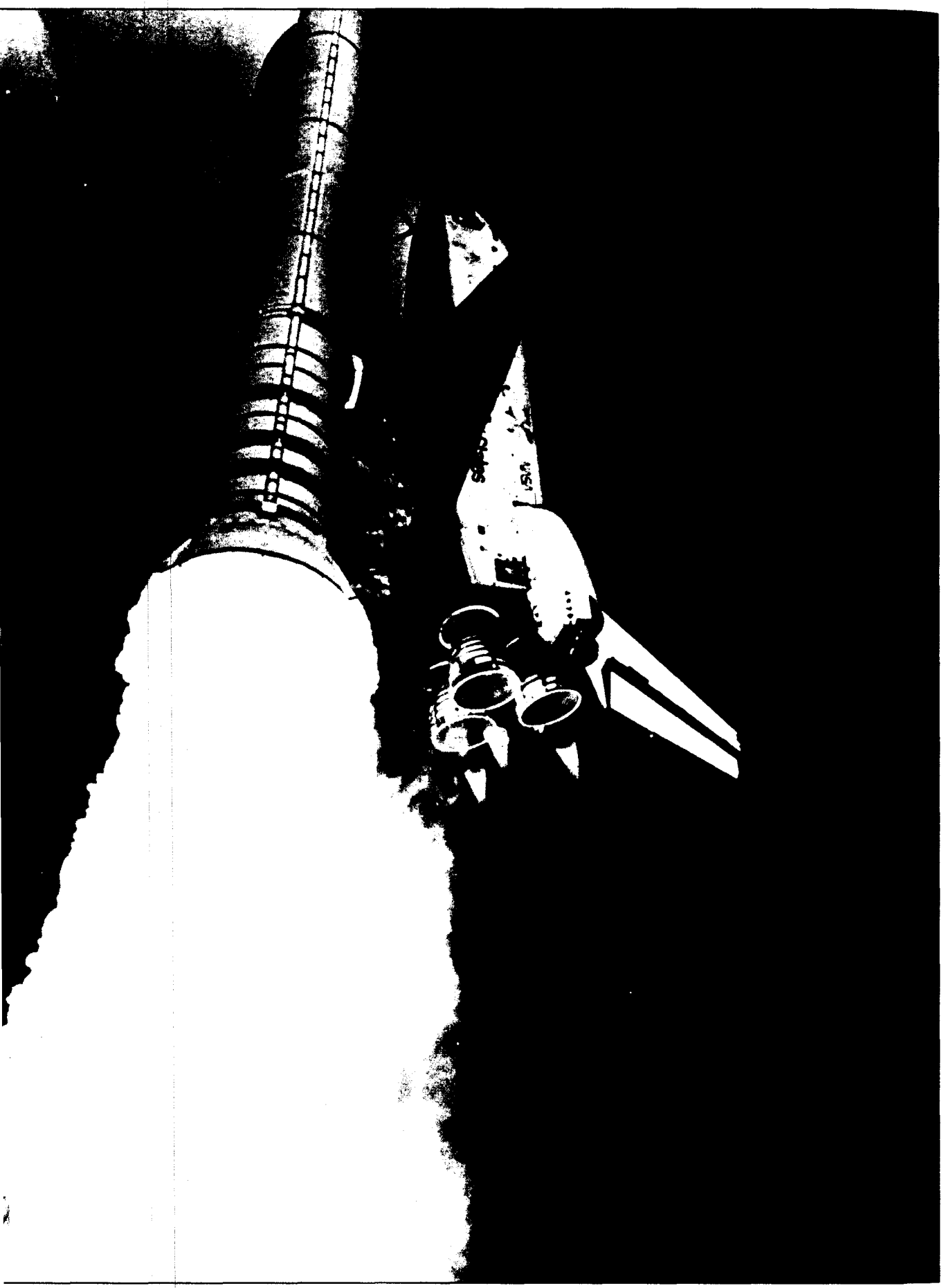
Figure 1
After one false start, Challenger *lifts off from Pad 39A on the afternoon of 29 July 1985.*

typical Florida thunderstorms had me convinced that we would not make it off the pad again. But computer and gyroscope problems were straightened out and the countdown finally proceeded to T=0.

Lift-off in the shuttle is gentler than one might expect. When the main engines ignite, the vehicle has a notable "twang" that results in a four-foot swing at the top of the orbiter. Several seconds later, the solid-rocket boosters ignite and the bolts are blown. At this point there is no question something is happening and, more important, will continue to happen, Figure 1.

Challenger lumbers smoothly off the pad, with no great jolt because of the massive weight of the vehicle at this

Figure 2 *Abort mode switch had never been used in actual flight prior to the flight of STS 51-F.*



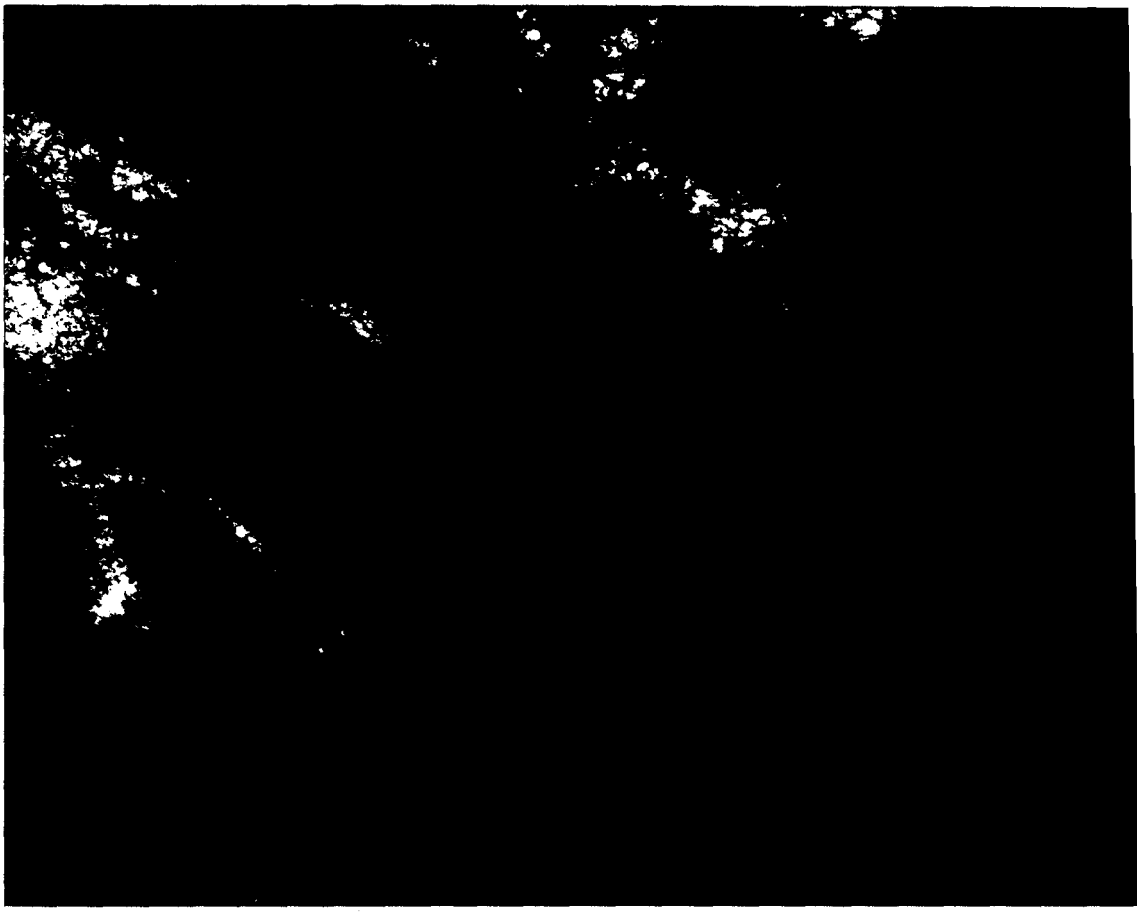


Figure 3A
Greek peninsula of Peloponnesus with southern section of central Greece visible at top.

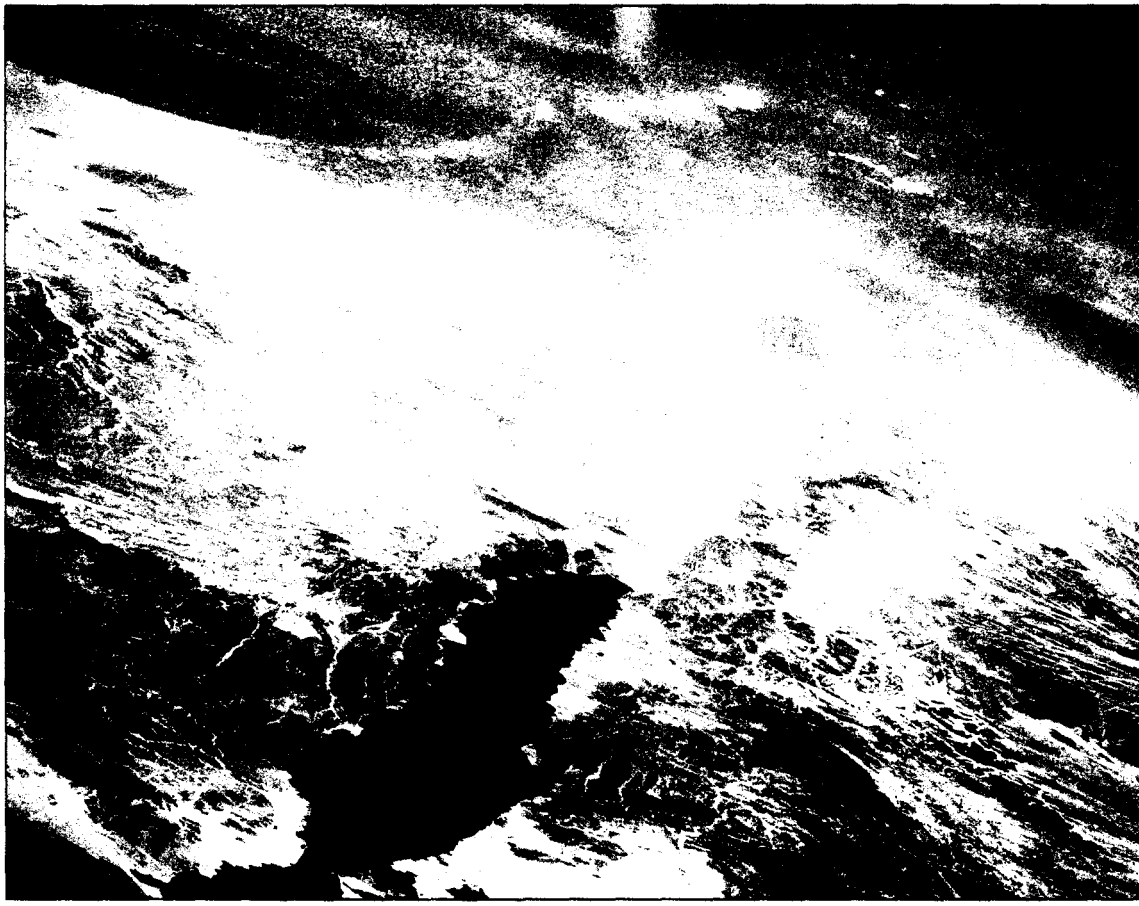


Figure 3B
Gulf of Aqaba with Sinai Peninsula to the left—Mount Sinai is in the range of mountains at the tip of the peninsula.

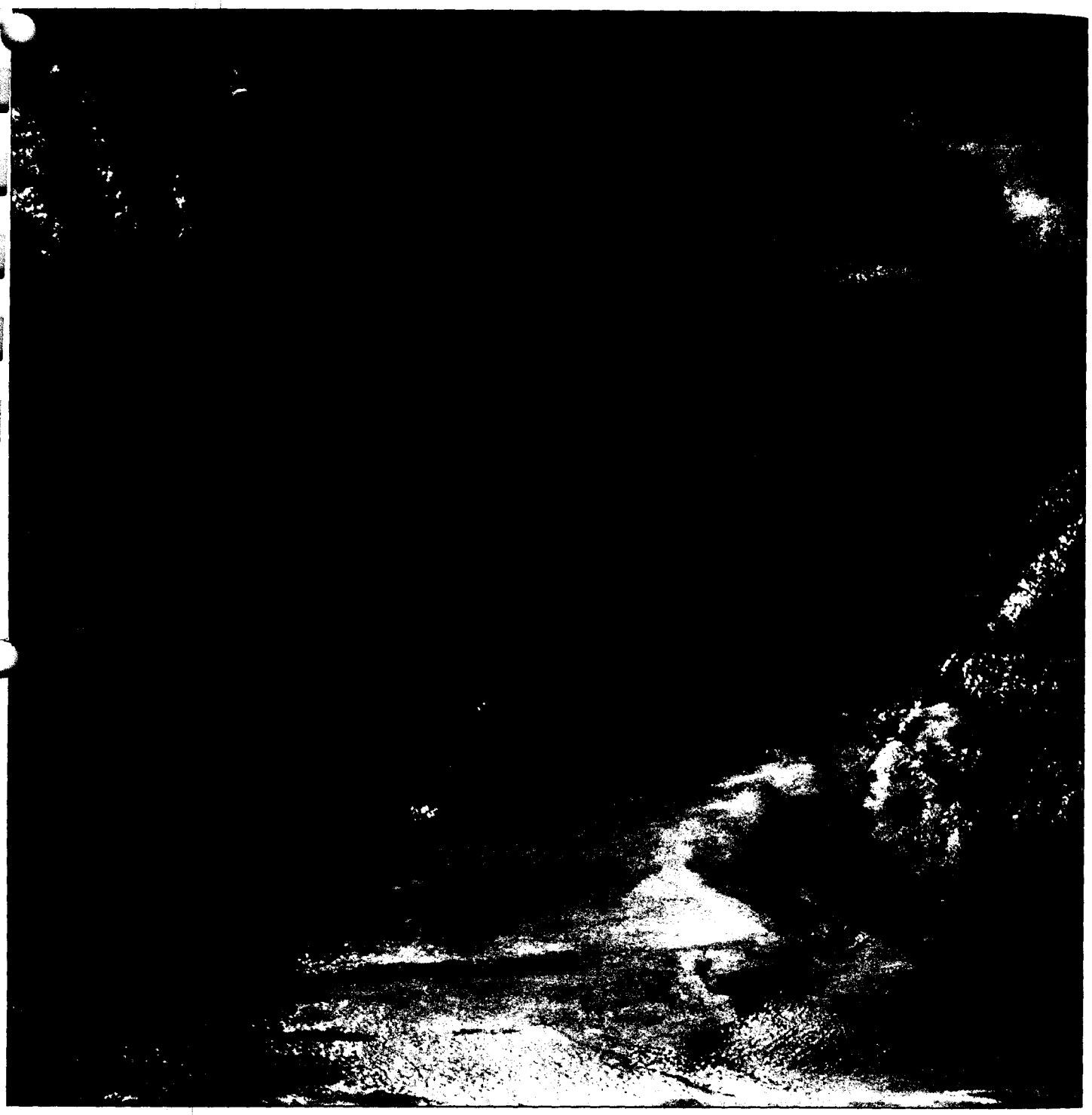


Figure 3C *Cape Cod Bay, Massachusetts—photo encompasses Boston and north as far as the New Hampshire border.*

point. A crash helmet protects the ears from deafening sound, but there is a tremendous feeling of power and thrust. Once the solid rockets drop away, more than two minutes after lift-off, the ride provided by the space shuttle main engines becomes incredibly smooth. But as things turned out *Challenger* was still not home free.

Just over five minutes after launch, one of *Challenger*'s main engines shut down. There was no doubt that something was wrong, even on the mid-deck, because the gradually increasing g-forces suddenly dropped off. The only question was *how many* engines were gone.

The call "Abort, ATO" was the best possible news at this point. Of the four possible abort modes, ATO (abort to orbit) meant that *Challenger* had sufficient altitude and speed to limp into orbit on the two remaining engines, Figure 2.

Unfortunately, this procedure calls for dumping more than 4000 pounds of orbital maneuvering fuel, crucial to

on-orbit operations and to the "ionospheric holes" experiment in particular. Dumping the fuel was required for two reasons: first to lighten the shuttle to ensure that it would make it to orbit and, second, to loft the big external tank into the Pacific between Hawaii and California where it would not be a threat to any populated area.

The resulting orbit, some 50 miles lower than planned, also had mixed results. The x-ray telescope experienced a lower cosmic ray background level and was able to make better observations while the coronal helium investigation recorded a weaker solar signal because of absorption of the helium diation by the atmosphere still above *Challenger*.

Orbital Operations

Once on orbit, unusual experiences came thick and fast. The first one I noticed was John Bartoe's face puffing up

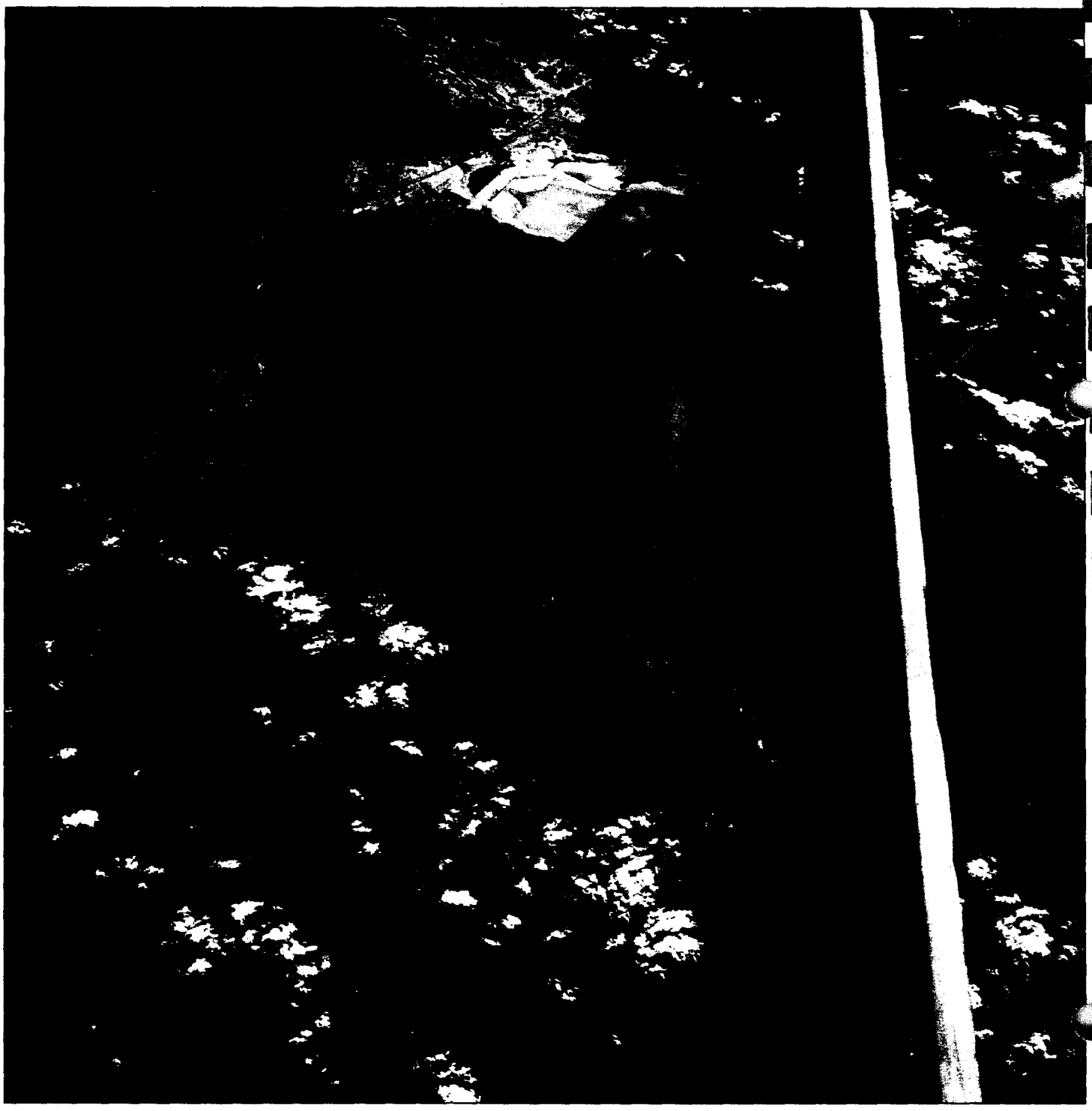


Figure 3D *Serving as a backdrop to the vertical fin of the space shuttle orbiter, Salt Lake City, Utah can be seen to the south (left) of the Great Salt Lake.*

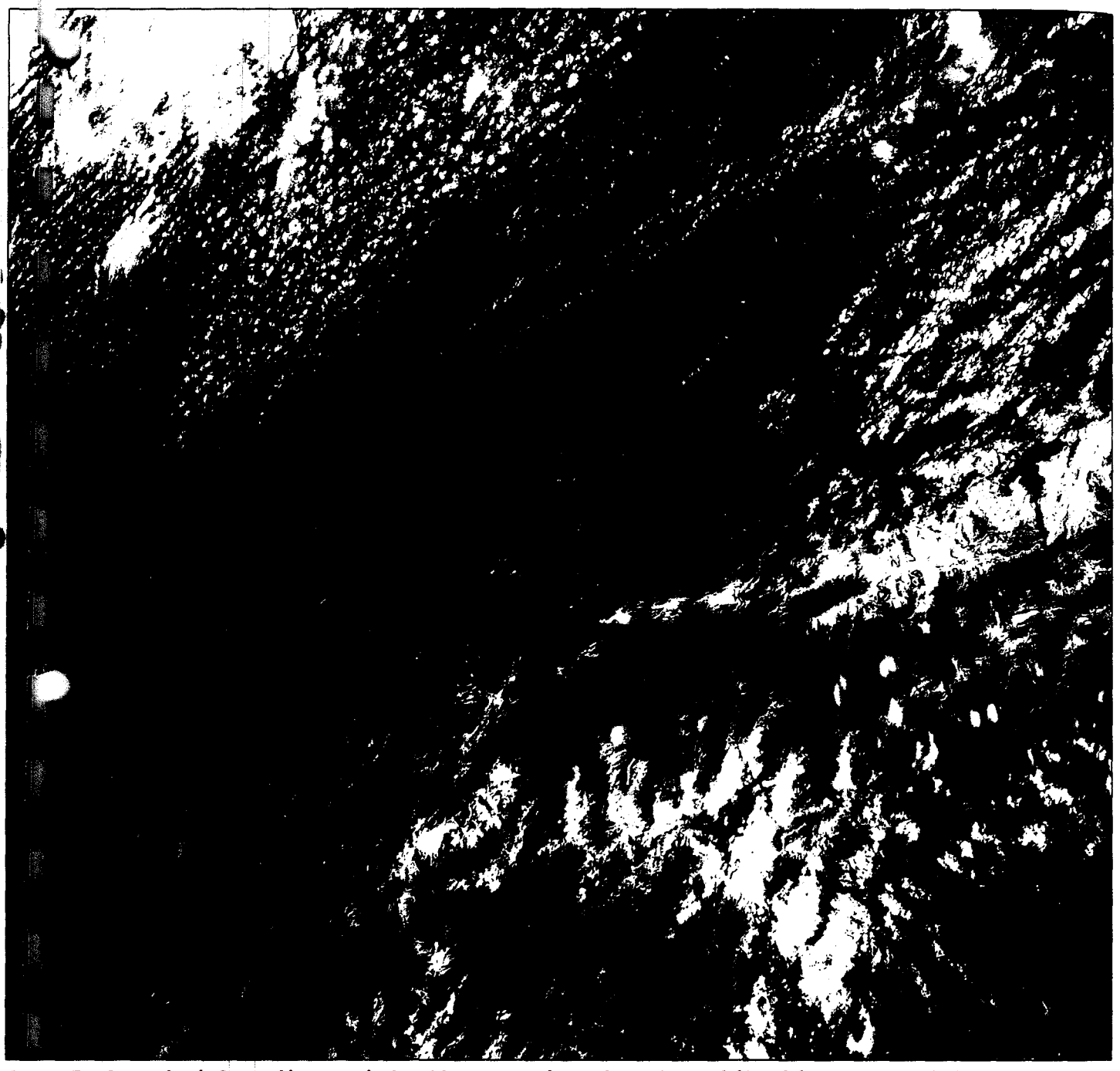


Figure 3E *Switzerland—Located between the Jura Mountains to the northwest (upper- left) and the snow-covered Alps to the south, Lake Geneva is at left-center with the Lake of Neuchatel northeast of it. The Rhone river can be discerned flowing west (from lower right) and then north into the east end of Lake Geneva. Mont Blanc is just southwest of the bend in the river.*

as his body began to adapt to weightlessness by redistributing fluids. The second, space adaptation syndrome, was less pleasant. In my case, it felt much like stomach flu. Nevertheless, here on earth you can go to work even though you feel lousy, and that is what must be done on orbit. Gradually, the symptoms decreased and by the third full shift normal gastro-intestinal functioning returned.

Despite the initial busyness of being in orbit, there was a moment to appreciate the view. Floating from the middeck, where there is only one small window, up to the grand view on the flight deck is exciting. Not only is it technically interesting, but the instruments, wrapped in white, silver, and gold, are an exquisite sight. As if this were not splendid enough, behind all of this technology is the majestic earth—a jewel of a planet. From space, where you can see a great deal all at once, you realize what a magnificent home we have. The colors, reds, browns, and greens, leap out at you. White clouds and the intense blue of the oceans are awesome and you cannot help but fall in love with our home planet, Figures 3A through 3H.

Yet another marvelous novelty of spaceflight is weightlessness. Until you

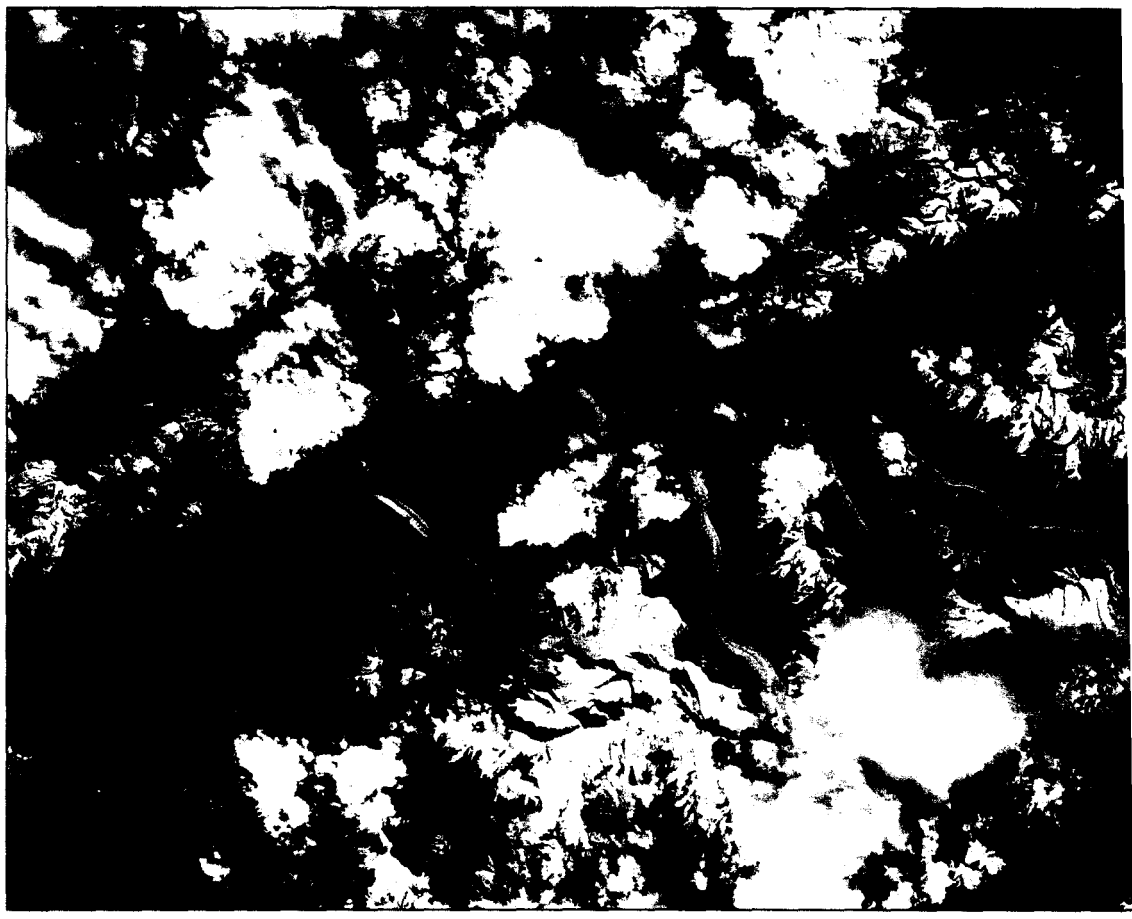


Figure 3F
Karakoram mountain range in Pakistan—note the glaciers moving through the valleys.

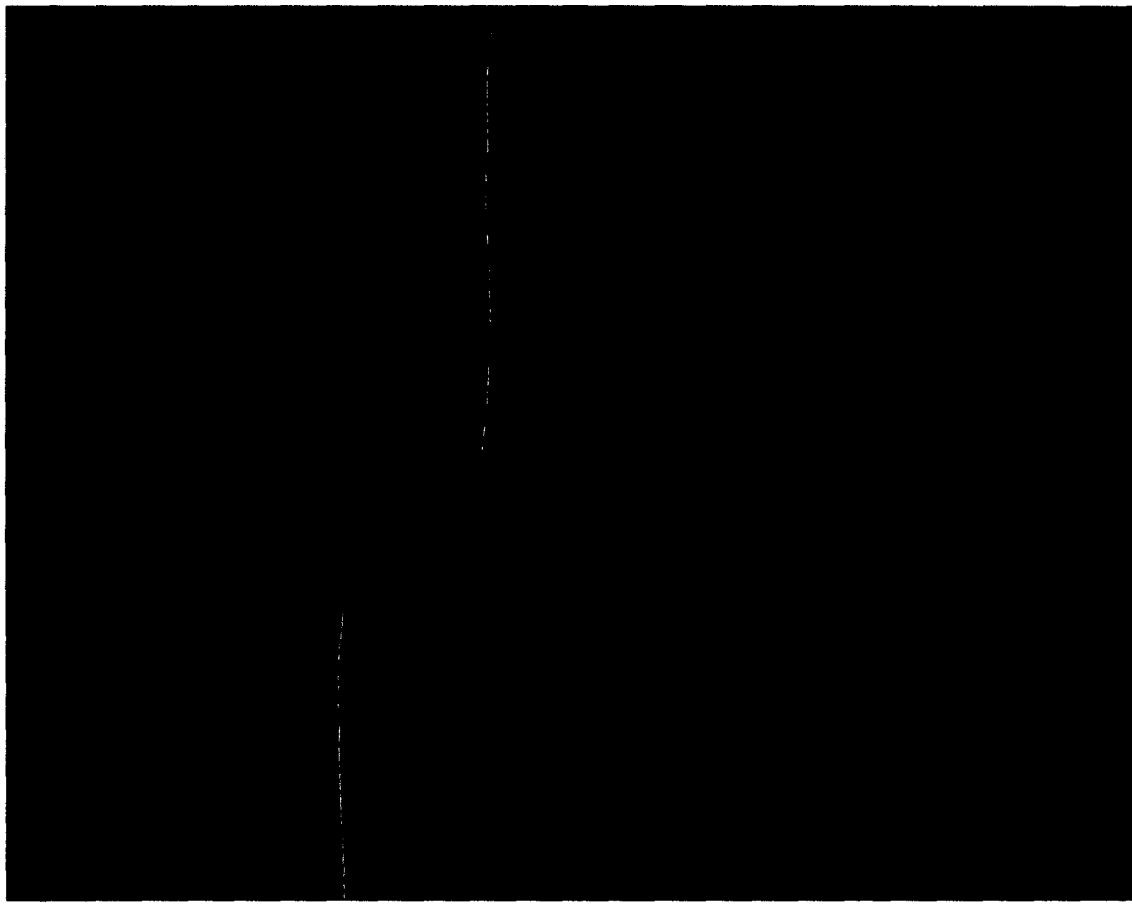


Figure 3G
Namib Desert on the southwest coast of Africa.

Figure 3H
"The Squid"—the Betsiboka River in Madagascar reveals poor land use practices with excess soil in its delta.

Figure 4
STS 51-F Crew—Top row: John Bartoe, Commander Gordon Fullerton; center row: Story Musgrave, [illegible] England; bottom row: Loren Acton, Roy Bridges, Karl Henize.

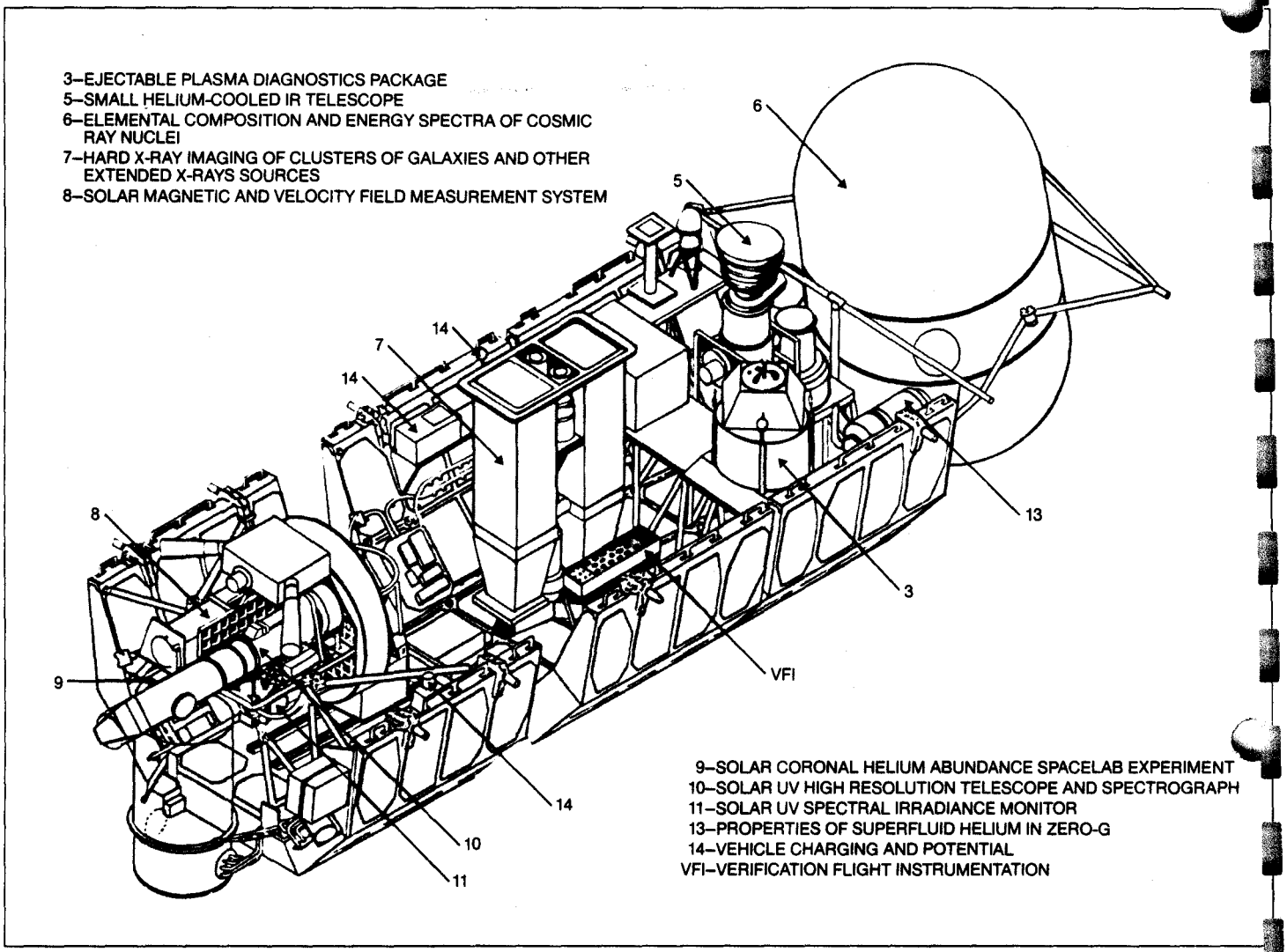


Figure 5 *Spacelab 2 experiments covered seven scientific disciplines, ranging from x-ray astronomy to a plant growth investigation housed in the orbiter mid-deck.*

get used to it, you tend to act as if you are swimming through air—trying to get some place by paddling. Not only does this get you nowhere, but you end up working against yourself by banging into things—often your crew mates! After a time you learn to move slowly and with a light touch.

It is important to relax and to stop the tendency to work against weightlessness. For example, if you want to stay in the same position, the natural tendency is to touch the floor. But that is entirely inappropriate because it causes you to exert a force on the floor which propels you upward. However, once you get used to being weightless, it is convenient, fun, and easy to manage. With a little practice, you can park a pencil or camera lens right before you and it stays there until you are ready for it again.

Weightlessness also allows a large crew (7 members on Spacelab 2) to operate efficiently in three dimensions. Spacelab missions, unlike other shuttle flights, operate in two 12-hour shifts. Each shift had 3 members, a payload and mission specialist as well as a pilot. Commander Fullerton acted as a swing member of the crew, Figure 4.

Twelve hours on duty was sufficiently demanding that once off-shift I was ready for a good "night's" rest. The remaining hours were filled with meal preparation, photography, and general housekeeping tasks. On an eight-day mission there is no need for leisure time. This was just as well because combining recreation with the heavy operational workload would probably have resulted in our getting in one another's way.

Even though there were new and exciting experiences to take in, the overriding feeling during the first few days was one of responsibility. There were so many people working hard in mission preparation and then replanning the mission, almost from scratch because of our late launch and lower orbit, that there was a profound desire to succeed so as not to disappoint them.

Of course, there are plenty of opportunities to make some pretty public mistakes while on orbit. More important, you can spoil some really good science. I made my share of blunders and tended to be more aware of them than necessary. After the mission, it took about two days to realize that all the great results people are telling you

bout are genuine and that they are just saying it to make you feel good.

A Smorgasbord of Science

Unlike the two previous Spacelab missions, Spacelab 2 did not have the pressurized laboratory in the cargo bay. Instead, *Challenger*'s bay was crammed full of scientific instruments, Figures 5 & 6. Part of the verification aspect of the mission was to see how combining a diverse mix of disciplines would work. It required some challenging mission planning, with the many trade-offs caused by different science requirements, resulting in the curious mixture of good and bad news brought about by the 17-day delay and the lower orbit.

Some experiments required nighttime operations, others daylight. Several required extensive crew interaction, while a few merely needed to be turned on and occasionally monitored.

For a scientist who has spent his career studying the nearest star, a Spacelab mission is an unparalleled opportunity to delve into an assortment of scientific fields:

Life Sciences—The first of these experiments concerned the metabolization of vitamin D and the loss of bone minerals. Without question, this was the most personal of all experiments for the crew, since twice in the mission, once early and once near the end, Story Musgrave would eagerly await the opportunity to draw blood samples from us.

The experiment postulated that loss of vitamin D during weightlessness, a very similar condition to that found in bedridden patients, led to weakened bones—one of the major deterrents to long-term spaceflight. Information on this process could lead to clinical advancement in the treatment of hyper- and hypo-thyroidism, osteoporosis, osteodystrophy, and rickets.

Preliminary analysis seemed to indicate that the loss of vitamin D was not a factor—at least not a major one.

The other life science experiment involved growing a miniature forest of pine trees, mung beans and oats to study the effect of weightlessness on lignin growth. Lignin is a structural polymer in plants that produces strength in wood, but cannot be digested by humans. A better understanding of this polymer could have an important impact on food production and industrial wood compounds.

Technology Research—At temperatures below minus 270.9°C helium be-

Members of Lockheed's SOUP investigation team (POCC team) review the initial data from the instrument on board Challenger. Left to right, Mike Levay, Ted Tarbell, and Jake Wolfson.

comes a superfluid and behaves in unusual ways. At this temperature, only 2.2°C above absolute zero, helium flows through pores no other fluid can manage, conducts heat with 1000 times more efficiency than copper, and can sustain five different kinds of sound waves instead of one in normal fluids.

These properties make it ideal for use in cooling spacecraft systems—especially detectors in satellites like the infrared astronomical satellite (IRAS). The strong gravitational field of earth hides these superfluid helium properties so proper experimentation can only be done in space.

High-Energy Astrophysics—Two experiments on board Spacelab 2 were designed to observe some of the most energetic processes in the universe through the detection of cosmic rays and x-rays.

The elemental composition and energy of cosmic ray nuclei experiment (CRNE), was known more simply as the "Cosmic Egg" due to the shape and size of the detector, Figures 5 and 6. Weighing over two tons, CRNE was the largest single instrument package carried by the shuttle thus far in the program. Cosmic rays carry data on some of the most crucial cosmological questions facing astronomers today, such as the evolution of the universe and the magnetic structure of the galaxy.

A key area of interest for the hard x-ray imaging of clusters of galaxies and other extended x-ray sources (XRT) was the "missing mass" phenomenon—another key cosmological question. Under current theory and observation, astronomers have identified only about one to ten percent of the expected mass of the universe. Stars, dust, and planets just do not add up to enough mass to explain the gravitational forces which are observed operating throughout the universe.

The XRT sought to image galactic clusters, especially the extremely hot intergalactic gases, which may identify a substantial percent of the "missing mass."

Infrared Astronomy—The small helium-cooled infrared telescope (IRT) provided astronomers with another look at the infrared sky which was sur-

Figure 6
The large egg-shaped object is the cosmic ray nuclei experiment. The helium-cooled infrared telescope is at bottom-center and part of the x-ray telescope is visible at bottom-left. The scene also affords a good view of the thermal protection system on the orbital maneuvering system pods and the vertical stabilizer.

veyed by the infrared astronomy satellite in 1984.

Infrared radiation, by virtue of passing through dust and particulate matter that screens out other parts of the spectrum, reveals information on galactic structure that is unavailable through the use of other wavelengths. It is the only radiation product available from the very cool accumulations of gas and dust which are the birthplaces of new stars.

Plasma Physics—Designed to map the plasma environment of the shuttle and earth, the plasma diagnostic package (PDP), Figure 7, carried 14 instruments of its own, and placed a heavy but exciting, piloting demand on Fullerton, Bridges, and Musgrave.

After release of the PDP from the shuttle arm, *Challenger* had to be piloted to intersect the same magnetic field line (plus or minus 30 feet) as the free-flying PDP, at a range of more than 1000 feet. This procedure called for the most precise formation flying of any shuttle mission thus far. Our pilots performed the operation with great success thanks to intensive preflight simulation and practice. Following this "fly-around" the PDP was recaptured without a hitch by Henize, using the shuttle arm.

The intricacies of the ionosphere were mapped using two active experiments—the vehicle charging and potential experiment (VCAP) and the plasma depletion experiments. VCAP was used to generate an electron beam while sensors on *Challenger* and in the PDP were used to measure the effect of the beam on the surrounding environment.

In the depletion experiment *Challenger* used its powerful orbital maneuvering system engines to poke "holes" through the ionosphere. (The neutral gases in the exhaust plume cause the ambient ions and electrons to recombine.) Radio astronomers can "see" through these holes and detect portions of the radio spectrum, especially in the low- and medium-frequency range, that are normally screened by the ionosphere. Five earth stations participated in this experiment.

Atmospheric Physics—Mounted with the three solar experiments on the instrument pointing system, the solar ultraviolet spectral irradiance monitor (SUSIM), measured the variations of the total UV radiation emitted from the sun.

While being only a small part of the sun's total energy, UV radiation is the prime heating source of the earth's upper atmosphere. In turn, this has important consequences for the weather system on this planet. It is obvious that the sun affects weather, but the mechanisms and consequences of the variation in solar output is far from understood. John Bartoe, my companion payload specialist on the flight, is a SUSIM coinvestigator.

Solar Physics—Ancient Incas called themselves the Children of the Sun. The Egyptians worshipped Ra, the mightiest of the gods, embodied by the sun. Despite their myths and expectations, the ancients were absolutely correct in the faith they put into the importance of the sun to life on earth. But the sun is far from the simple ball of fire it has been thought to be through most of our history.

The solar experiments were designed to dissect the sun level by level—delving into its magnetic fields, energy transportation mechanism, atmosphere, sunspots, and other intricacies.

One of the most perplexing solar mysteries is the heating of the corona—a thin, tenous atmosphere extending several solar radii into space. The coronal helium abundance spacelab experiment (CHASE) was designed to measure precisely the amount of helium in the sun's corona. While the visible "surface" of the sun, called

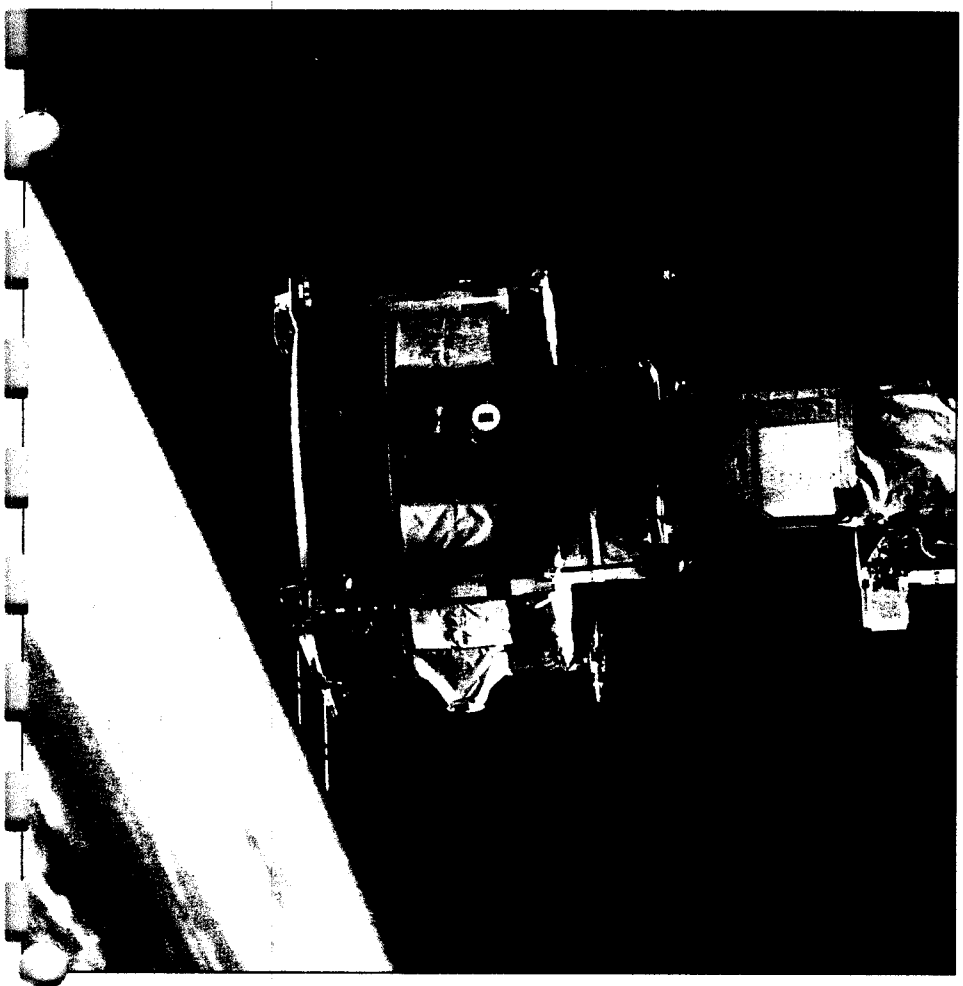
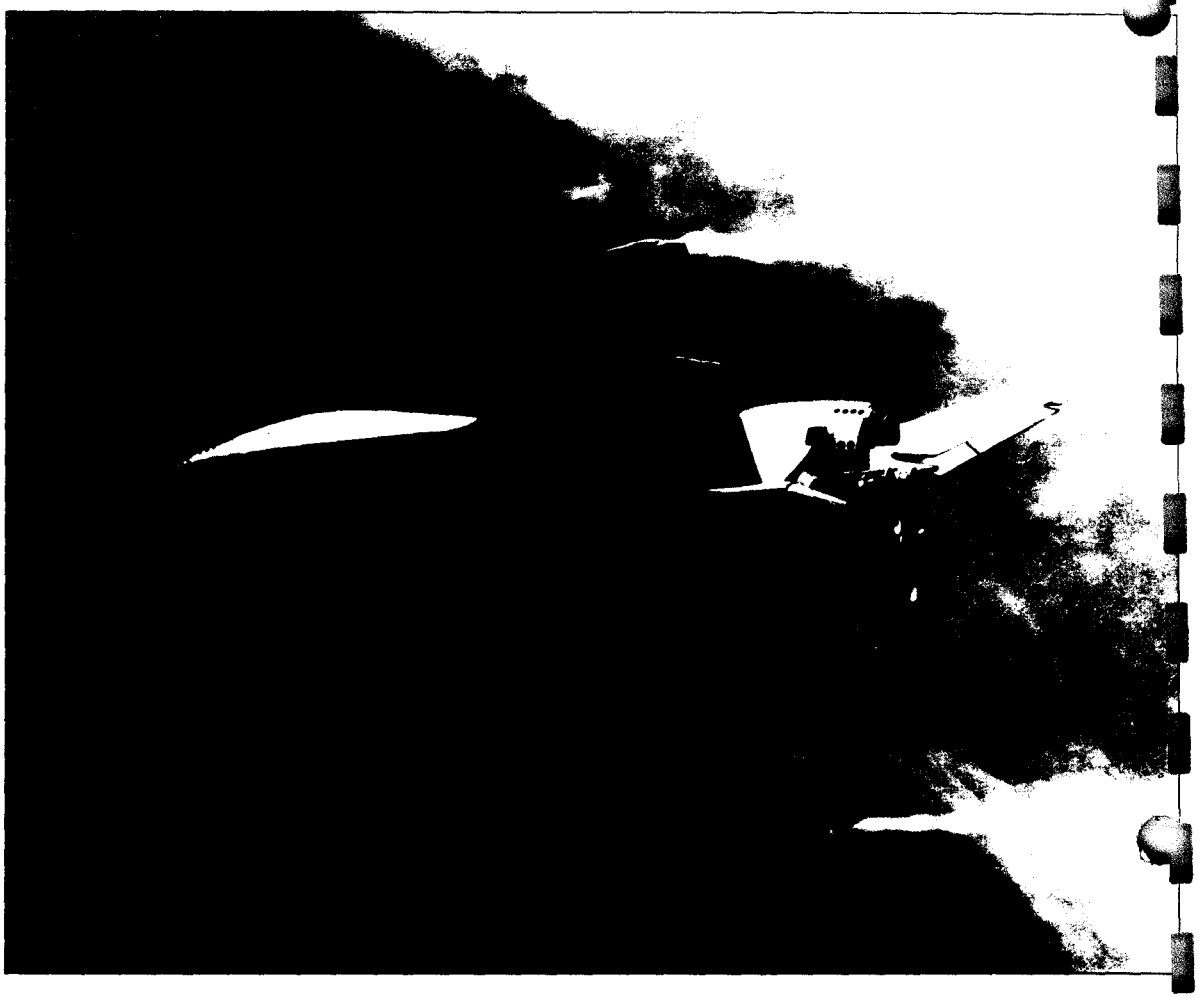


Figure 7 *Plasma Diagnostic Package which required precise positioning by* Challenger's *pilots—note the thin layer of atmosphere, only eight-miles worth, that protects the earth.*



the photosphere, is about 5000°K, the corona, extended from the surface, somehow heats to more than 2 million°K.

The amount of helium in the universe has been postulated to have remained nearly constant since the beginning of time. Measurement of the exact amount of helium in the sun, impossible to do from the ground, is also a matter of cosmological significance.

The solar ultraviolet high resolution telescope and spectrograph (HRTS) was designed to specifically look at the region between the chromosphere (the region just above the photosphere) and the corona. This violent transition region holds valuable clues to the energy transport mechanism in the corona and the acceleration of the solar wind.

The instrument pointing system (IPS), which carried the solar instruments, received the most attention during the mission and was partially responsible for the record number of commands and software patches transmitted during the Spacelab 2 mission. Designed and built by Dornier System in Germany, the IPS, Figure 8, initially could not acquire the sun. Fixing the IPS became a predominant crew and ground activity. Gradually, as software patches were added, the IPS came to full strength and met its one-arc-second pointing objective. Verification of this system was crucial to the success of Spacelab 2.

An IPS observing sequence began immediately at sunrise. Once the system was fully operational, five to ten minutes of adjustments were necessary for solar acquisition and for setting up the solar instruments. The remainder of each 54-minute sunlight pass was devoted to operation and monitoring the performance of the solar telescopes, Figure 9.

Nighttime passes were used to plan the observing sequence for the next daylight period. Out of the 126 orbits, more than 66 were devoted to solar observations or IPS testing. Most of the other instruments were automated or controlled from the ground and required substantially less monitoring and commanding from the aft flight deck.

SOUP's On!

Once *Challenger* had limped into orbit, instruments were activated, doors opened, and the procedures for orbital operations quickly begun.

The Lockheed solar optical universal polarimeter (SOUP), was powered on normally. Designed by Dr. Alan Title, of the Solar and Optical Physics Group at Lockheed's Palo Alto Laboratory, SOUP was designed to look at the greater detail of the sun's surface.

SOUP works by making pairs of solar pictures, either electronically with a solid-state television camera or on film. Because light is polarized by magnetic fields, when one image is subtracted from its opposite, the difference is a map of the sun's magnetic

fie[illegible].

The flight plan called for all of the electronic images to be transmitted to the ground during the mission. Using this data, data from other instruments, and data from a worldwide solar observation network, targets for each pass would be determined in a near real-time basis and integrated with a pre-launch plan.

In Houston, a team of Lockheed scientists and engineers was gathered in the Payload Operations Control Center (POCC). Years of preparations and recent simulations were complete and, now that SOUP was on orbit, the first test sequence began 3.5 hours into the mission.

In the middle of the first crew handover, SOUP stopped running. No indication of failure was received, the telemetry just quit! The POCC team (see Figure on page 14), in the midst of a busy turnover procedure between the blue and red shifts, immediately began tracing signals, sorting through misleading telemetry, and initiated a

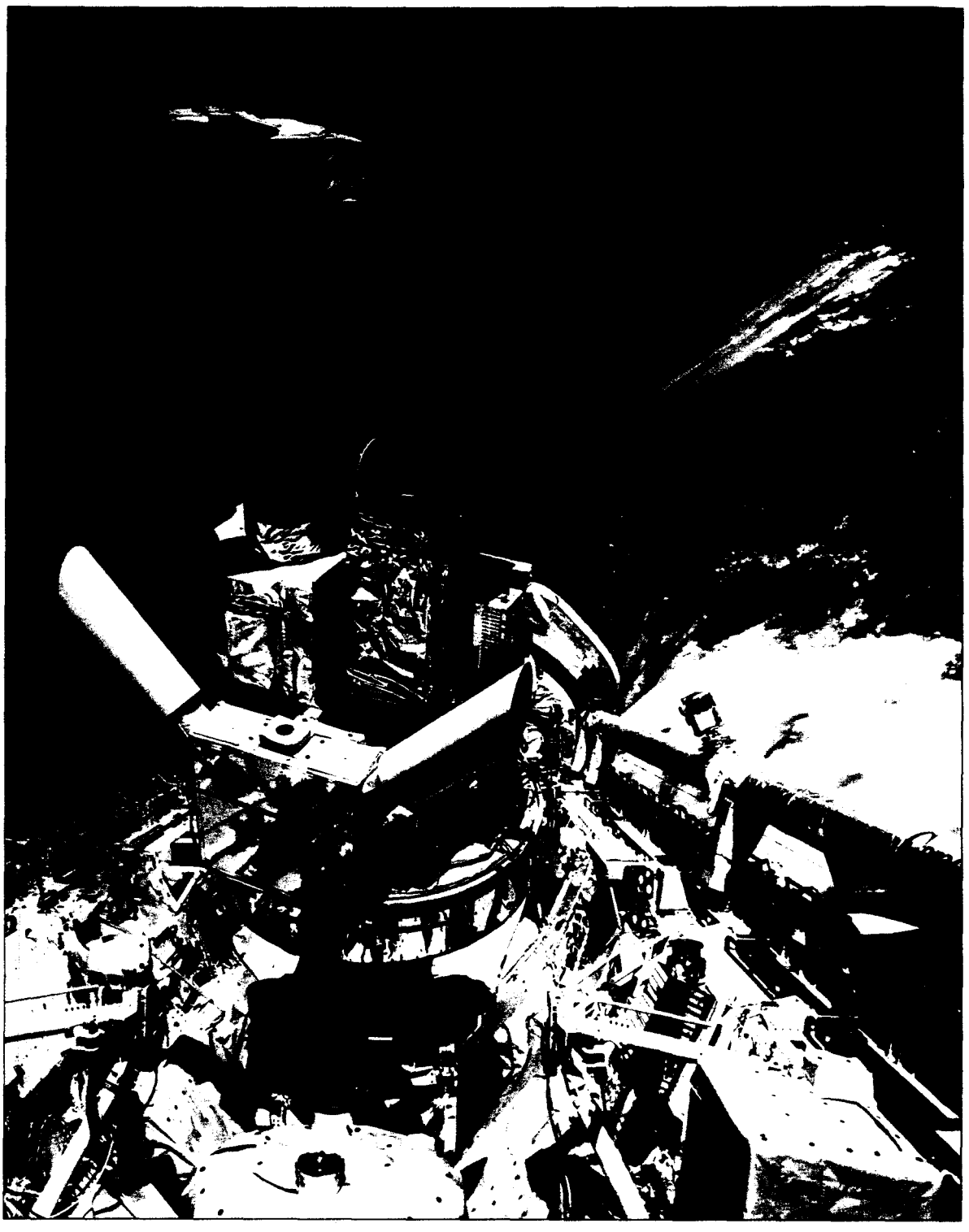


Figure 8
Dornier System-built Instrument Pointing System, with four "up-and-running" solar experiments. SOUP is the silver-covered instrument with open door.

thorough analysis of the electrical system, in search of an explanation.

The normal shifts of 12 hours suddenly turned into 16-hour marathons. The major difficulty lay in the fact that there was no downlink telemetry. POCC members could not tell if the instrument was too hot or too cold, whether any of four crucial fuses had blown, or if there was a software command, either in Lockheed or Spacelab computers, that should not have been there.

Two rather dramatic rescue alternatives were discussed and implemented. The first, on Day 3, involved shutting off the power to SOUP and turning it back on. This procedure required also turning off the other three IPS-mounted instruments, entailing the additional concern that these other solar telescopes might not restart. This procedure was ineffective.

The second attempt involved a restart of the remote acquisition unit, a Spacelab "black box" responsible for data handling. All of the instruments on the IPS would be affected with this procedure. The attempt was made on Day 5. All of the instruments came back up, but not SOUP. At this point POCC members began writing the trouble shooting procedure that would trace the fault once the instrument was back on the ground.

Efforts to understand the problem never ceased, especially among the SOUP ground team. As already mentioned, during Flight Day 6, an orbital maneuvering system burn was planned to investigate holes in the ionosphere to allow for better radio telescope observations. After this powerful "kick in the pants" (6000 lb of thrust from two engines), Gary Kelly, a SOUP team member, asked that an activation command be sent, yet again. (Kelly requested the same activation sequence at the start of each of his shifts.) Both the crew and the ground controllers noticed the results at the same time. Despite being in the midst of a busy change of shift meeting on *Challenger*, Payload Specialist John Bartoe noticed SOUP's door open, but before he could ask for an explanation, crew interface coordinator Barbara Cobb asked for visual confirmation of telemetry signals, indicating the telescope was being supplied with power.

When SOUP telemetry began coming into the POCC the instrument temperature registered 4°C, the team was lucky it had not frozen. Disbelief was the major emotion on the ground and in space. The orbiter was in the midst of a 12-hour cold-soak flight orientation, so the real work with SOUP could not begin immediately. Once the initial shock was over, a determination to make the best of the remaining time replaced it.

With the wise use of consumables, the mission had been extended for one more day. This allowed 17 full orbits for solar observation, and a great many concessions were made to the SOUP experiment so that the team could make up for lost time.

Procedures for calibrating the instrument had not been implemented, so a direct voice link between Ted Tarbell in the POCC and the crew was initiated to speed along the procedure. Sections of SOUP were turned on very slowly and cautiously, but once the data started rolling in there was little time to evaluate it, as was planned—quick glances were stolen and the next picture was assembled.

Solar images from SOUP were displayed on the cabin monitors and looked like static images compared to the jitter levels delivered by the IPS pointing alone. A self-stabilizing pointing system in SOUP which allowed this accuracy will become mandatory on all future solar telescopes that require such fine pointing.

Despite the initial problems, SOUP managed to do what solar physicists have been attempting to do for almost two centuries—obtain distortion-free photos of the sun's surface, Figure 10.

A few times a year, astronomers are lucky enough to get just the right combination of good seeing, clear skies, and solar activity to make a sub-arc-second resolution picture of the sun. Until Spacelab 2 there were few of these photos, and never two in a row. Thanks to SOUP, there are now more than five hours worth of the best white-light images of the sun ever taken. These results will allow Title and his colleagues to study the fine features of the sun and build up an ev-

Figure 9 *Solar "pass" sheets outlined observing sequence for 54 minutes of daylight during each orbit.*

Dr. Alan Title, SOUP principal investigator, explains preliminary results to the news media shortly after the mission.

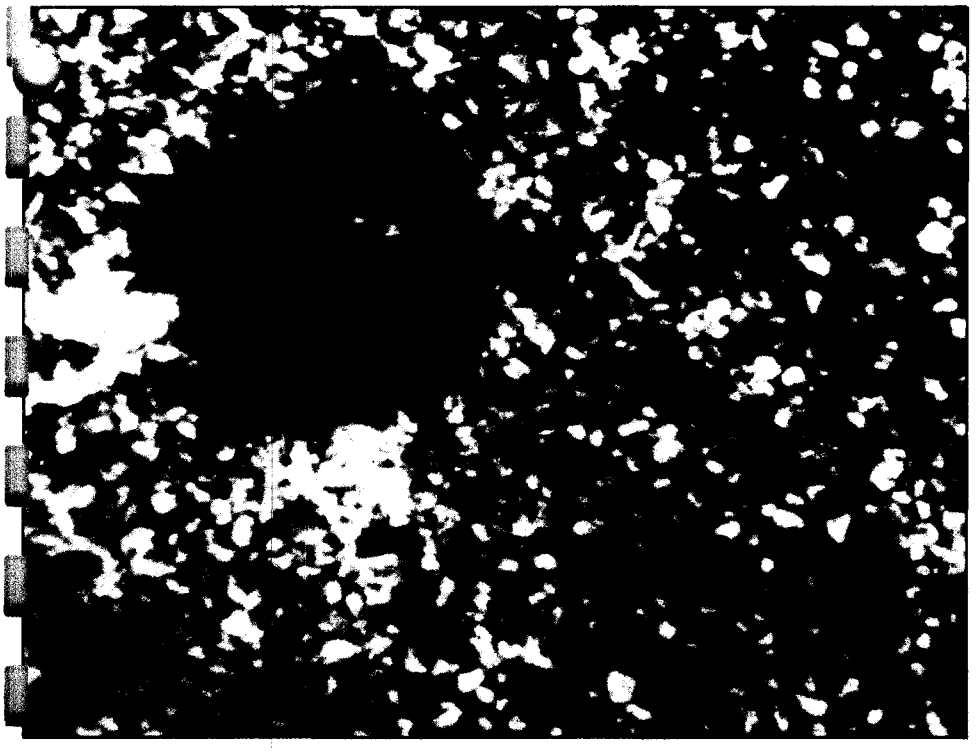


Figure 10 SOUP photo of sunspot with sub-arc second resolution.

Figure 11
A gyro-stabilized Mission Specialist—Story Musgrave. Here, Story is "flying" the 14,000-rpm centrifuge used to separate the blood samples he earlier had collected from four of the crew.

olutionary idea of how features like sunspots appear. The photos, about 6400 of them, have a resolution of one-third of an arc-second, which translates to features of about 200 kilometers on the sun.

No reasonable explanation has been discovered for the behavior of the instrument. Once the Spacelab 2 instruments were powered down to return to earth, an attempt to turn SOUP on again was made. It did not respond. Yet, on the ground, after the flight, SOUP has been activated dozens of times, responding perfectly every time. (Perhaps there was a "smart" solder ball that decided to wreak havoc with equally "smart" engineers.)

Diversions and Other Matters

Weightlessness provides ample opportunity for exploring some basic physics principles and having terrific fun in the process. An earlier crew (STS 51-D) actually made a videotape of how several common toys reacted in zero-g to help children understand the effects of weightlessness.

Story Musgrave, a truly intrepid space traveller, provided many diversions throughout the mission. The first would make a good physics problem for advanced undergraduates or beginning graduate students. After stabilizing himself in the center of the middeck area, floating free of all encumbrances, he proceeded to turn himself 360 degrees, simply by waving his arms. At first, it was not apparent how he could do this since he touched no walls and could not move enough air with his flailing arms to push himself around. (For those still stumped, the answer has to do with angular momentum.)

A second demonstration by Musgrave involved the use of a centrifuge to stabilize himself as he "flew" around the cabin. The centrifuge, used to separate blood samples drawn from crew members, could also be used as a gyroscope. With the device securely grasped by Musgrave, random motions imparted by other crew members were removed by the spinning centrifuge, Figure 11.

Liquids are always the source of

Figure 12 *No taste test was made on board* Challenger, *just evaluation of "carbonated beverage dispensers." As you get used to weightlessness, "up" becomes less important!*

much amusement on spaceflights. They quickly form small balls and are very easily set into motion by a small breeze. One of the experiments on board called for the testing of two new carbonated beverage dispensers designed by two leading soft drink manufacturers, Figure 12. After the test was completed there was time to explore liquid reactions with carbonation bubbles inside. (There was no desire to drain the cans after testing the dispensing methods—warm soda in space is just as appetizing as warm soda on earth.) Setting the carbonated liquid spheres rotating with a jet of air resulted in the bubbles gathering on the axis of the spinning blobs as centrifugal force acted on the heavier liquid.

Another popular experiment involved Tony England's amateur radio station, Figure 13. Many astronauts are "hams" and several flights have had portable setups taken along. Setting up his station in the mid-deck, England was able to contact some 200 operators around the world on his off-duty hours. One particularly enjoyable feature of his rig was a slow-scan television transmission capability that

Figure 13 Mission Specialist Tony England contacted ham operators around the world during off-duty hours.

Figure 14 *Pilot Bridges with only one of many teleprinter messages.*

Figure 15 *Gordon Fullerton charting* Challenger's *consumables, hoping for an extra day on orbit.*

allowed some welcome pictures of our wives to be transmitted up from Houston.

Years of planning had gone into the complicated operation of the Spacelab 2 instruments. The combination of a late launch and a lower orbit made many of our on-board documents almost useless. On board *Challenger* was a teleprinter used primarily to uplink data to the crew. Without it, parameters for such events as orbital burns would have had to be taken down by hand. With the extensive mission replanning taking place in Houston, this would have required hours of transcribing by the crew. Spacelab 2 had the dubious distinction of being the first mission to use an entire roll of teleprinter paper, Figure 14. The mission was well into its second roll by landing time.

Once in orbit there is a strong desire to stay there as long as possible. From the very start of the mission, the leader in the effort to conserve precious consumables was Commander Fullerton. Throughout the mission he could be found floating about the cabins switching off unnecessary lighting and equipment, exhorting the crew to conserve, Figure 15. For most of the mission, several consumables were very close to red-line values. (These red-lines include provisions for unanticipated extra days, such as a delay made mandatory because of bad weather at the landing site.)

When word came that the mission could be extended an extra day if the crew agreed, there was no debate whatsoever. As the mission developed, the extra day was invaluable for the Lockheed telescope which did not come on until we were 5½ days into the mission.

Returning to Earth

Perhaps the funniest aspect of spaceflight is cleaning up. During eight days on orbit, things gradually emerge from every corner and pocket in the orbiter. They are used, then disposed of, set aside for further use, or put close to where they belong (but not quite). The orbiter was by no means in disarray, but it was just like any other working lab—with that "lived-in" look. Finding all of this miscellaneous gear and stowing it in its proper location—garbage containers, "Return-to-Houston" bags, film containers, etc.—was an adventure. Seven people were floating in every direction gathering all and looking for the proper place to stash it. Imagine having to clean up after an eight-day party when the landlord is expected at any minute, and you will have an idea of what it was like.

The sensation of re-entry and landing in the space shuttle is an adventure in itself. Once the powerful orbital maneuvering engines had slowed the orbiter sufficiently to fall out of orbit, the re-entry went smoothly, but with a lot of "pilot-talk" on the flight deck.

Challenger has slightly better aerodynamic properties than a brick, but Commander Fullerton's touchdown was the smoothest todate. *Challenger*'s

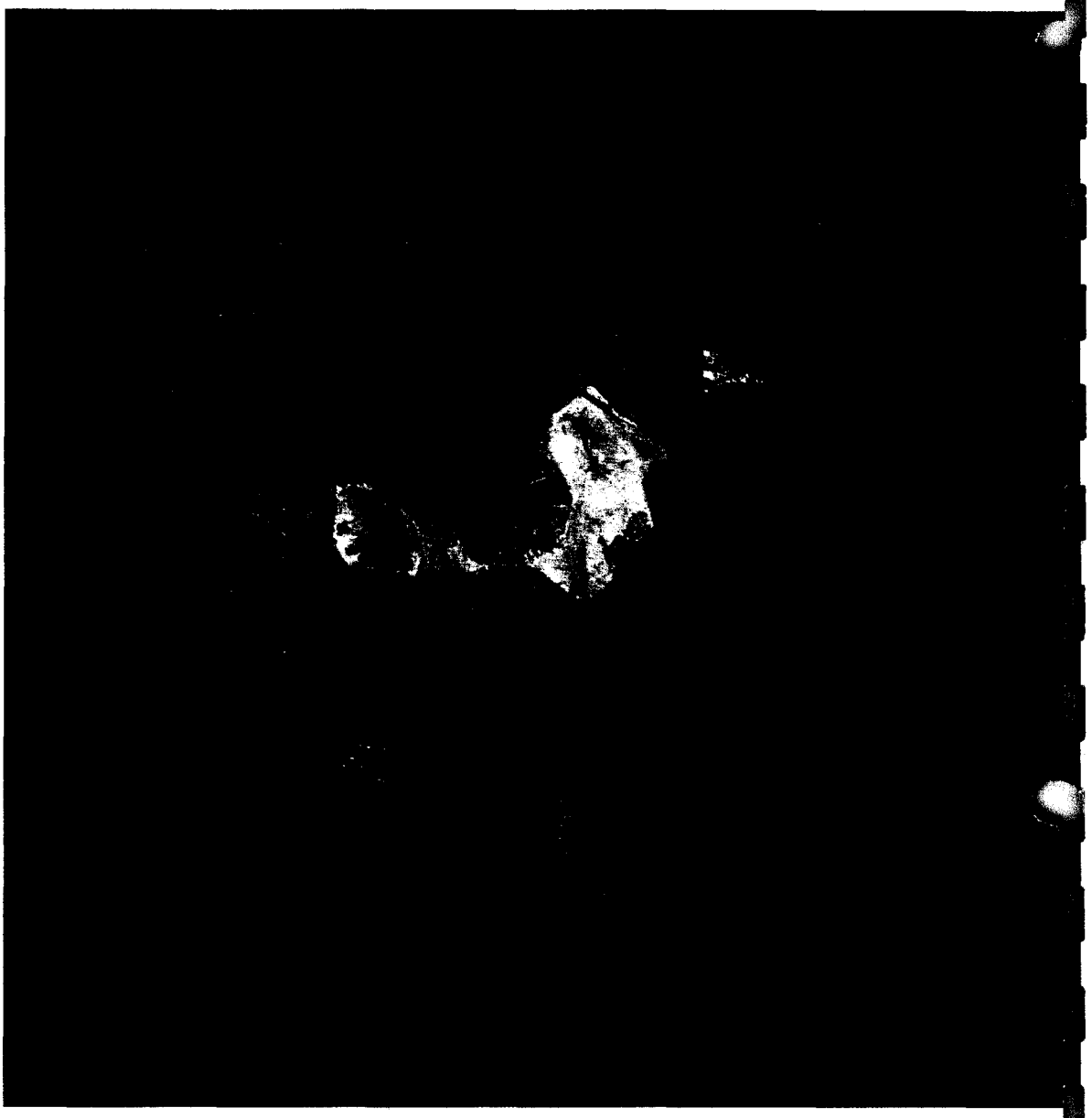


Figure 16
Edwards Air Force Base, site of Challenger's *return to earth, from 150 miles above.*

sink rate was only ten inches per second. If it were not for the change of sounds, the crew on the mid-deck would not have realized *Challenger* had touched down, Figure 16. During re-entry and landing, everything gradually becomes very heavy. Tony England had taken on the task of filming the re-entry on the flight deck, but the camera just became too difficult to handle and he was forced to stop before long.

Land legs are another matter. Just like adapting to zero-g initially, readapting to one-g can be unpleasant. Different people react in different ways. In my case, the reaction was vestibular, with the orbiter seeming to spin wildly with only a slight head motion for several tens of minutes after landing. There is still no way to predict how individuals will react but I am told that my experience was not unique.

Scientific Return

Spacelab 2 will teach solar physicists volumes about the sun. Mountains of data await analysis, extending our knowledge in ways we cannot even now imagine. Data from this mission will probably be used for decades, especially in the study of the complete 22-year solar cycle.

There are practical applications as well. Understanding the principles of a star involves the same basic physical principles applicable to all gases. In essence, the surface of the sun is simply hot gas, with its motion ever changing just like the atmosphere here on earth.

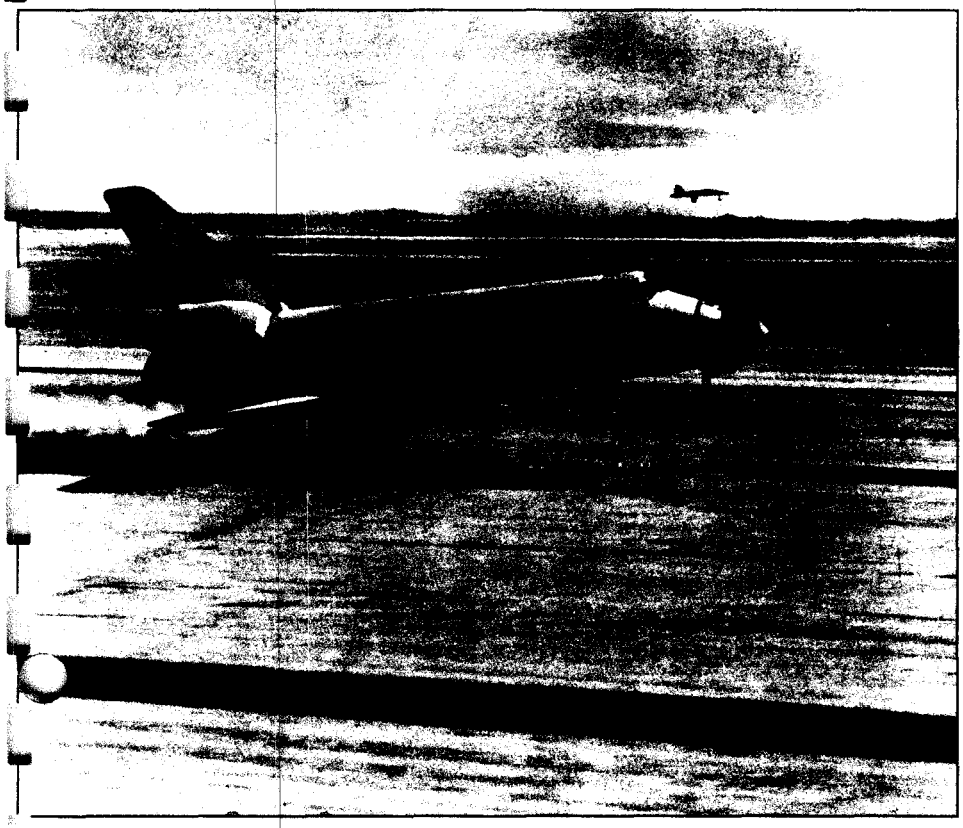
A closer example is the dynamics of hot gases in a jet engine. Spacelab 2 did not study the sun to improve the efficiency of jets, but since the basic principles of hot, turbulent gas are the same, there may be an application yet unknown. After all, the sun is simply a very large fusion reactor, and understanding how it magnetically "bottles up" tremendous energies may help some day to make fusion a viable earthly power source.

Weather prediction techniques will also improve over time, using the data from Spacelab 2. In combination with local conditions, the sun drives the

weather here on earth (and throughout solar system). As the sun passes through its 22-year sunspot cycle, it alters its radiation output, leaving signature patterns here on earth. (The evidence has been found locked in tree rings in the western United States and in sediment layers in Australia.) As we increasingly understand solar cycles, it will help scientists to understand and to predict terrestrial effects.

There is surely an intrinsic value to the study of the universe that is impossible to quantify. This is the fulfillment of the quest for knowledge of human kind. As long as the universe holds secrets there will be a need among men and women to try to unravel the mysteries. As Huygens tells us, the best use of that knowledge may be to understand ourselves better.

Rarely, except when faced with catastrophe and war, do humans band together so closely and with such dedication as they do in spaceflight. Those of us who actually travel in space are merely the ones who are fortunate to justify efforts and fulfill the dreams of countless others eager to explore the unknown.



DR. LOREN ACTON is a senior staff scientist and a senior member of the Lockheed Palo Alto Laboratories. Acton's flight on Space Transportation System 51F culminated some seven years of anticipation and intensive preparation for a mission which has produced unique solar data that will be invaluable to space physicists for many years to come.

Acton received a B.S. degree from Montana State University in 1959 and a Ph.D. in Astro-Geophysics from the University of Colorado in 1965. At Lockheed he is responsible for an experimental research program in space astronomy, including all scientific, technical, and management aspects of the work.

He was named by NASA in 1978 to serve as a payload specialist on the Spacelab 2 mission. He serves on national and international committees and panels for solar astronomy, and currently is presenting for NASA some of the results of the Spacelab 2 solar experiments before various scientific bodies.

Among his professional affiliations are the American Astronomical Society, International Astronomical Union, Sigma Xi, Astronomical Society of the Pacific, and the American Association for the Advancement of Science.

STEPHEN J. PEHANICH is a public information coordinator with the Public Relations organization of LMSC where he is responsible for the planning, preparation, and dissemination of information related largely to space sciences. In fulfilling this assignment he worked closely with Loren Acton during pre-mission, mission, and post-mission activities, dealing with international and national news media at launch and mission control sites, and at LMSC's Sunnyvale and Palo Alto facilities.

Pehanich received his B.A. degree in Political Science from the University of California at Los Angeles in 1977, and his Master of Business Administration degree from the University of Santa Clara in 1984. Prior to joining LMSC he was with the Lockheed-California Company where he provided public relations support for the L-1011 program at Calac's Palmdale final assembly facility.

His additional responsibilities at LMSC include the planning and execution of publicity programs for the Hubble Space Telescope. An avid amateur astronomer, he is active in the San Jose Astronomical Association.

TESTIMONY OF JOHN H. MORRISON
IN SUPPORT OF
MONTANA STATE UNIVERSITY
AT LEGISLATIVE BUDGET HEARING
HELD FEBRUARY 2, 1987

Mr. Chairman, Members of the Committee, my name is John Morrison of Helena, Montana. My profession is Civil Engineering.

Since 1923, when I entered Montana State College as a undergraduate student, I have been interested in the development of Montana State. I have been very closely associated with the activities of the college, as Alumni President, Director of Endowment and Research and member of the President's Council. I have the privilege, honor and responsibility of receiving three degrees from Montana State College. Bachelor of Science Degree in 1927, Professional Degree as a Civil Engineer in 1931, and the first Honorary Doctor of Engineering given by the University in 1968. The three years following my graduation in 1927 were spent as an instructor in the Civil Engineering Department of Montana State College. Between 1930 and 1945, I was employed by the State Highway Department as a Bridge Designer, Bridge Project Engineer, Chief Bridge Engineer, and finally Bridge Engineer until September of 1945. At that time, I entered private engineering practice and founded the firm of Morrison-Maierle Consulting Engineers.

Our firm has had a successful engineering practice which I believe can be attributed to the professional quality of our staff. The majority of our key people are graduates of the Montana State University. The attached list names twenty professionals on our staff who are graduates of Montana State University.

The training and experience which our professionals received at MSU have enabled our firm to compete with some of the top engineering firms in not only the United States, but internationally. To keep our staff busy, we have, of necessity, worked outside Montana in most of the western states and in the international arena.

Internationally, we have ongoing projects in Zaire and Lesotho, and have completed work in eight other foreign countries including:

South Viet Nam

Syria

Saudi Arabia

Zaire

Lesotho

Sudan

Tanzania

Egypt

Mauritania

Caribbean Islands:
Antigua
St Vincent
St. Lucia

For the past several years, about 1/2 of our company income has been the result of the work done in these foreign assignments.

Our firm has consistently been listed among the "Top 500" Engineering Firms in the United States. This is a testimonial to the excellent training which our key personnel received at Montana State University. Our concern is that our ability to

compete and survive with MSU graduates depends on the quality of education they receive. We won't be able to compete with Montana educated staff unless MSU provides quality instruction, training, research and has adequate physical plant. The current and projected cuts are disasterous. Engineering faculty salaries are low by any standard, and professionals will sacrifice only so much for the quality of life we enjoy in Montana. MSU competes in the market place for students also, and if a quality education isn't funded, then the top students along with top faculty will be leaving the state. Can we afford the brain drain?

As a business person, I am well aware of the financial bind with which we are faced in the State of Montana. Our firm, for example, is about 1/2 as large as it was a few years ago. primarily due to a slow down in Montana work. However, those of us who are still in the state would like to carry on and see the quality of education preserved that we have established. We are willing to foot the bill. We realize this means new taxes. I am sure that the majority of the citizens of the State of Montana are proud of the record our school has made and will support funding the quality of education and training which we have built up during last 50 or 60 years.

Respectfully submitted.

John H. Morrison

MORRISON-MAIERLE, INC. EMPLOYEES
MONTANA STATE UNIVERSITY GRADUATES

NAME	GRADUATION DATE	TITLE
BARNETT, DAVID L.	1976	STRUCTURAL ENGINEER
BELL, SCOTT	1984	ENGINEER
BERRY, TIMOTHY R.	1973	CHIEF ENVIRONMENTAL ENGINEER
CARLSON, DAVID R.	1964	CHIEF CIVIL/TRANSPORTATION ENGR.
EAGLE, HAROLD L.	1943	CHAIRMAN OF THE BOARD
ENRIGHT, WILLIAM G.	1971	ENGINEER
FOSTER, RODGER C.	1972	VICE PRESIDENT, BUSINESS DEVELOPMENT
GREEN, PHILLIP C.	1962	VICE PRESIDENT AND BRANCH MANAGER, BILLINGS
HARRINGTON, JAMES G.	1975	DIRECTOR OF DATA PROCESSING
HEINECKE, JOHN H.	1979	ENGINEER
KEITH, C. WILLIAM	1956	SENIOR VICE PRESIDENT AND CHIEF STRUCTURAL ENGINEER
KRAFT, ALBERT N.	1950	SENIOR VICE PRESIDENT, INTERNATIONAL
MAIERLE, JAMES A.	1970	SENIOR VICE PRESIDENT, FINANCE
MORRISON, JR., JOHN H.	1955	PRESIDENT
MORRISON, SR., JOHN H.	1927	CONSULTANT TO THE BOARD
RICHMOND, TERENCE W.	1972	BRANCH MANAGER, KALISPELL
SCHUNKE, JOHN R.	1975	BRANCH MANAGER, BOZEMAN
STELLING, DAVID S.	1979	AIRPORT ENGINEER
WATSON, T. MICHAEL	1971	ENGINEER
WETSTEIN, WILLIS J.	1957	SENIOR VICE PRESIDENT

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1. From a personal viewpoint, I now have five great-grandchildren. The oldest, in about six years, will be making a decision as to where he would like to carry on with his education. As he doing well with math and science, it is possible that he may choose Engineering. I hope his Dad, Grandfather and I (all graduates of MSU Civil Engineering Department) will be able to recommend Montana State University. We won't, unless quality education is preserved.

2. When I graduated from college, there were no Consulting Engineering firms in practice in Montana. Communities relied on the Charles T. Main's, Black and Veatch's, Burns and McDonald's from the East and Mid-West to do their engineering work. We now have probably 50 in-state firms of various disciplines providing these services. This couldn't have been accomplished without MSU, and if MSU dries up, so will this profession as far as Montana is concerned.

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Mervin G. Gunderson
P.O. Box 1405
Belgrade, MT 59714

February 1,1987

Committee Members
Legislative Budget Panel

Honorable Members,

I wish to take a few minutes of your time to express the concerns I have with reguard to the current financial situation at Montana State University. I am very cognizant of the current strife the State of Montana has to face during these financially tight times. It would appear, at least axiomatically, that reductions in budgeting for the University system would be the proper course of action. It is, however, a much more expensive alternative then first percieved.

When the initial budget cuts were set in motion at Montana State University virtually every department was looked at. Decisions were made to make reductions in the areas that would allow the University to maintain the greatest amount of academic credibility while striving to keep the Physical Plant and personnel on an even keel. Vacancy savings allowed us to hold the loss of classified personnel down a little but people lost jobs. More and more personnel will be faced with the prospect of no employment if budget cutting is not curtailed.

The maintenance of the Physical Plant has been put into such straits that most repairs are of an emergency nature. Departments on campus are financially unable to request needed improvements. Since the service shop at Montana State University depends on the departments for a majority of their work requests the service shop is placed in a very precarious situation. The disrepair of the campus will eventually escalate exponentially at a much larger cost to the taxpaying public which includes me.

The cutbacks in personnel are creating some very difficult situations. Departments are placed in the position of delaying work output. There is no decrease in the requests departments are receiving but the output must be met by employees that have to not only produce their normal functions but pick up the added requirements of the vacated positions. The employees of the University system fully realize the budgetary problems of the State. That is little consolation to the employee that must face the wrath of irate students, faculty, and public.

Stress levels are rising within the campus community. There is a lack of certainty. Each time we comply with the required budget cuts the toll on the remaining personnel heightens. Tempers seem shorter, frustration increases, and the stress

levels keep rising. To make matters worse is the uncertainty of future budget cuts. Employees do not have the stability that the University used to offer. Many excellent faculty and staff are actively seeking other employment. This is a matter that should be of utmost importance to the State. It took many years to acquire the myriad of talented people on the campus. Their exodus will certainly be more rapid.

Finally I would like to impress on the committee that the actions taken by the administration at Montana State University are not merely a facade or "smoke screen". The problems being dealt with are real. The University must not be forced into mediocrity. The future of education in Montana demands excellence. To continue down the short sighted path of budget cutting will serve only to undermine the basic precepts that higher education stands for. I, therefore, respectfully request that you give the highest priority to fully funding the University system.

Respectfully

Mervin G. Gunderson

Mervin G. Gunderson

ASSOCIATED STUDENTS
OF
MONTANA STATE UNIVERSITY

FEBRUARY 2, 1987

ORDER OF PRESENTATION

I. Nancy Korizek.....ASMSU President, Introduction

II. Erica Cantrell.....Laurel High School

III. Pat Rooney.....Electrical Engineering

IV. John Rogers.....Political Science, Pre-Law Option

V. Julie DalSoglio.....Masters of Public Administration

VI. Jerry Cummings.....Industrial Arts Education

VII. Bill Rankin.....College of Agriculture, Animal Science

VIII. Wade Ayala.....All-American Wrestler; Secondary Education

IX. Owen Letcher.....School of Architecture

X. Nancy Korizek.....ASMSU President, Conclusion

Testimony of Erica Cantrell, Laurel, MT high school student, before the Joint Appropriations Subcommittee on Higher Education, of the Montana Legislative Assembly February 2, 1987

My name is Erica Cantrell. I am a senior from Laurel High School. I am here to represent my peers from around the state.

In a time when you are attempting to draw more high school graduates to Montana's colleges, I have some sobering statistics for you. Out of my class of 116 students, 40% of them intend to pursue a higher education, 17% plan to stay in-state, and approximately 25% are undecided in their plans, and their futures rest largely upon the developing status of our state's college and university system. These figures are not only indicative of Laurel High School, but also reflect an unhappy trend around Montana.

We are all making decisions about our future, and that often brings conflict. We WANT to stay in Montana, where our family and friends and heart's are. But we also want the best education we can get. It is your job to try and combine these two options.

As you make decisions in the following days and months, I ask you to keep the 25% "undecided" foremost in your minds. This is the group that will be the deciding

factor for Montana;s universities in the years to come. Several legitimate thoughts have been voiced. Ranking high amoung these is the concern about which programs will be eliminated from the schools. It would be a grave mistake to do away will "unique" studies; if Pharmacy and Scandinavian Studies are cut, for instance, would-be students of Montana universities will be forced to go out of state.

I myself will be attending Arizona State University instead of the University of Montana for one main reason: lack of stability in Montana Schools. I love Montana and would love to spend my life here, but my education means to much to gamble on. I, and many like me, refuse to be hit during our junior year of college with the realization that our majors no longer exists.

As you try to sort out our situation, remember that thousands of high school students are following your choices closely. What you decide to do will change lives. For some, it means the difference between trying to make something of themselves or just settling for the situation they are in. I leave you with a quote from one Laurel High School senior: "If funding is cut and courses are dropped from Montana's colleges, I will have no chance for a rewarding, life-long career."

Testimony of Patrick Rooney, MSU Electrical Engineering
Before the Joint Appropriations Subcommittee on Higher Education
of the Montana Legislative Assembly February 2, 1987

My name is Pat Rooney. I am a junior at MSU from Helena majoring in electrical engineering. I feel very lucky to be at school that is so highly regarded for its engineering program and be so close to my home at the same time. the excellence that was present in the engineering program when I entered is still present, but recently I have seen signs that this excellence may be threatened. In my program I have seen retired professors hired to teach because the department cannot afford to bring someone in from out of state. I have labs that previously were taught by professors that now are being taught by graduate students. Outside of my program I see students who have trouble getting into English classes and overcrowded Speech Communication classes. These are the signs of degradation I am seeing. Not serious now, but these things do have an impact.

You may be surprised to know that there are two electrical engineering firms in Bozeman. A student in the MSU EE department began working for one of these firms, Montana Laser Optics, not long ago. One of the functions of Montana Laser Optics is to test optical equipment. The company decided rather than buying one of these damaged testers they would build one themselves. The company believes their damage tester is good enough to be sold and is now trying to market

the product to larger companies. This type of innovation has a place in Montana's future. Right now laser research is being done at MSU.

In order to attract high-tech companies to Montana we must have institutions necessary to provide support and train for those companies workers.

I attended Oregon State University last year on the National Student Exchange program. Corvallis, Oregon, home of OSU is also the home of CH2M Hill, one of the world's largest engineering firms of its kind. CH2M Hill was started by two graduates of the OSU engineering program. I could not help but draw parallels between Montana Laser Optics and and CH2M Hill--Bozeman, MT and Corvallis, OR. We have got to maintain the support for MSU if we expect to benefit from its products.

Right now the recruiters that visit MSU are not being turned away by our budget troubles. However, as one recruiter I spoke to said, they will be watching MSU very closely to see whether the quality at MSU suffers as a result of this fiscal crisis.

If the quality of MSU is truly hurt by lack of sufficient funding, not only will graduates be greeted by fewer recruiters at MSU but Montana's hopes of building new industry here will be in jeopardy also. I hope you say no to more cuts and say yes to Montana's future.

Testimony of John Rogers, MSU Political Science Student Before the Joint Appropriations Subcommittee on Higher Education on the Montana Legislative Assembly February 2, 1987

Chairman Nathe and members of the committee. I am John Rogers, a senior at MSU majoring in the field of political science, and I have come here today to tell you about the impacts of the budget crisis on the political science department at MSU.

In general terms, political science is a core discipline found in almost any university and college worthy of the name. Like English, Speech, Math, History, and Economics, a Political Science program imparts basic knowledge and skills that are central to a college education.

In more specific terms, the importance of the discipline to MSU's mission to provide a complete and quality education is manifest in the fact that there are 146 students currently enrolled in political science compared to 133 one year ago. In the Fall of 1987 there were 809 students enrolled in political science courses. Stated another way, approximately 8.1 percent of the approximately 10,000 students currently enrolled in the Fall Quarter were in political science. In 1987, compared

to the year before, three programs in the College of Letters and Sciences experienced gains in enrollment: Biology (2.1%), Chemistry (1.Ø), and Political Science (22.2%).

POLITICAL SCIENCE IS COST EFFECTIVE EDUCATION

In these times of limited money for all kinds of public services it is important to emphasize that political science is a cost effective operation. Current faculty salaries total approximately $183,ØØ (these include the $32,ØØØ being paid to three adjunct faculty, none of whom are full time employees in the department). This faculty generates about 8,ØØØ student credit hours at a cost of approximately $22.88 per sch compared to the MSU average of approximately $4Ø per sch.

WHAT THE BUDGET CUTS WILL MEAN TO POLITICAL SCIENCE AT MSU

At this point, the three adjunct faculty slated for termination teach approximately 14 undergraduate courses (most of the requirements for graduation).

In more specific terms, the termination of the three adjunct faculty will mean the elimination of the Prelaw

option. This option currently has 62 undergraduates and provides courses for all individuals interested in attending law school. As it stands now, unless the adjunct positions are restored, a major element of this and any political science department will cease to exist. Prelaw would not be the only casualty. Faculty presently involved in the MPA program would have to teach undergraduate courses, forcing the elimination of the MPA program.

With these cuts, Political Science will be seriously hampered in delivering its share of the University Core Curriculum. By not completing all required core curriculum courses, a student cannot graduate from MSU.

SUMMARY

To briefly summarize:

1. Political Science is central to any university no matter what the size.
2. Political Science is growing in enrollment and is a cost effective program by any standard.
3. The cuts announced by President Tietz on December 15, 1986 will mean elimination of the MPA program. Prelaw, an area central in importance to any political science department, will cease to exist.

I stand before the commitee as a student deeply worried about his future. A college degree is my step to a brighter one. College isn't a luxury, but a necessity in the 1980's. A person just can't expect that a high school diploma will ever be enough. My family doesn't have a ranch or business to keep their children employed. My future is entirely ependent on the education I'm receiving right now. Without it, my prospects grow that much dimmer. As a student, I am asking the committee to stop this lingering gloom over the universities. If the intent is to permanently downgrade our institutions of higher learning, then announce it and be done with it. If your intent is to preserve the university system, then have the courage to fight for higher learning by finding the money that will assure that indeed Montana will have a future.

TESTIMONY BEFORE THE APPROPRIATIONS SUBCOMMITTEE ON

HIGHER EDUCATION

FEBRUARY 2, 1987

Mr. Chairman and members of the committee, my name is Julie A. DalSoglio and I am a Masters of Public Administration graduate student at Montana State University. I know that I am not the first nor will I be the last student to testify to this committee about the effects of the current budget crisis on the Montana University System. However, in this particular case what appears to be an appropriate budget cut is in fact a major program revision.

I would like to emphasize from the beginning of this testimony that under the proposed termination of funding for adjunct faculty in the College of Letters and Science at MSU there will be no MPA program in Helena or on campus. This is in spite of the fact that the Political Science department was asked to continue the on-campus program and maintain a presence in Helena. With the elimination of $32,000 for adjunct funding, the five remaining tenured faculty members of the Political Science department will not be able to sustain the MPA course offerings while absorbing the undergraduate course load. What does the loss of the MPA program at MSU mean to the university system?

First is the elimination of a program in which 30-40 MPA graduate students per year on-campus and in the Helena Interuniversity program is currently enrolled.

Second is the elimination of the only interuniversity program in the system. The Helena program for in-service public employees is the only joint UM-MSU university program and is designed to train public servants,

especially mid-career government personnel.

Third is the elimination of a highly productive, low-cost program. The MPA graduate program currently operates at a cost of less than $8.00 per student credit hour, one of the lowest cost programs in the system. Moreover, the program is highly successful with at placement rate of 98-99 percent. The program was scheduled for national accreditation in 1986 but lost the opportunity with the elimination of a tenure track line position during state-wide budget cuts in June. Additionally, four graduate students have been chosen in the last three years to receive Presidential Management Internship awards. The Presidential Management Internship program chooses 250 students nationwide each year to enter into management training positions with the federal government. Last year two MSU students were chosen. The only other graduate program in the nation to send two students to Washington, D.C. was Yale University.

The elimination of the Masters of Public Administration Program at MSU is a reality under the current proposals for budget cuts. I believe this cut is representative of the impacts of other cuts in other programs throughout the university system. Graduate programs, and in this particular case the MPA program, provide another aspect to the university system and higher education in Montana that is often overlooked. Graduate programs offer the challenge to Montana's best and brightest to apply knowledge and creativity in the solving of this state's technical, economic and political problems.

This legislature asked the university system to develop the best graduate programs available to the state with limited funding. The MPA program met this challenge. The students of Montana and this university administration are now asking the legislature to provide basic funding to continue the programs. Can you meet our challenge?

Testimony of Gerald Cummings, MSU Industrial Arts/Technology Ed.
Before the Joint Appropriations subcommittee on Higher Education
of the Montana Legislative Assembly
February 2, 1987

Mr. Chairman and members of this committee. I am Jerry Cummings, a senior at M.S.U. majoring in the field of Industrial Arts/ Technology Education. I am an older student and Vietnam Veteran, who returned to school to become an Industrial Arts teacher. I wish to stay in Montana and begin a teaching career next year. My program is in a period of transition, moving from a traditional Industrial Arts program to the national trend of Technology Education. A traditional program stresses very skill-specific activities in woods and metal, teaching psyco-motor, hands-on skills. Technology Education is the n .ional trend and mandated at MSU, developing technological literacy and creative problem solving skills using technical means. We still use hands-on activities as a vehicle for learning, but our labs also stress math, science, communication skills, and skills necessary to function in a high tech society.

The Industrial arts department at Montana State is the leader in Technology Education since beginning the change to Technology Education, back in 1978. Montana State Industrial Arts program is also an acknowledged leader in the Rocky mountain region in Technology Education. A recent graduate of the department is now at Western Montana in Dillion implementing Technology Education at that college. We are linked with a nationally known junior high school technology education program, in Haley Idaho. Each year we send two of our student teachers to this program to learn from a nationally acclaimed teacher. We have two recent graduates who are in national leadership

position in Greece, New York, and Fort Collins, Colorado. Fort Collins is the home of Colorado State University which is producing Industrial Arts not Technology Education teachers.

The Industrial Arts department at Montana State is the only source for teachers inservice training and updating. The instructors of this department provide leadership through out the state for teachers of Industrial Arts to keep current. This is vitally important for me as a new teacher next year here in Montana.

The faculty of this department secured $335,000 in grants this year to implement Technology education in this state. For every one dollar that you invested, this department brought in $1.25. These grants paid off to teachers throughout the state by providing new computers, software and inservice training this winter, in order to update programs in the state. This summer our department will put on the first ever Technology Education summer camp for junior high school students.

What is the pay off for Montana to invest in Technology Education at Montana State?

1 We must educate our children to allow them to function effectively and contribute in a meaningful way to improving the well being of this state and nation.

2. We must have a highly educated in state labor force if we are to attract clean high tech industries to Montana. With technology , we won't have to sell our environment to save our economy.

3. The Industrial Arts Department at Montana State University by example is graduating national leaders in Technology Education for the betterment of the state and nation.

4. The Industrial Arts department is providing the leadership and inservice training throughout the state to help teachers look to the future.

This has been a peak educational experience for me to come here today to speak to you. I thank you for your time and I thank my department for the quality education that I have received at Montana State University.

Sincerely,

Gerald Cummings

Gerald Cummings

Testimony of Bill Rankin, MSU Animal Science Student

Before the Appropriation Subcommittee on Higher Education

February 2, 1987

Mr. Chairman and members of the committee, my name is Bill Rankin. I am majoring in Animal Science/Science Technology at Montana State University. Having grown up in a rural community near Sunburst, Montana, I have always had a great deal of respect for agriculture and appreciate its role in the Land Grant University System.

Although agriculture is the state's leading industry, enrollment in the College of Agriculture is small and is growing smaller compared to other major areas. This may reflect our state's declining economy and students' confidence in our Ag programs. However, this should not be a factor in determining its importance in the Montana University System. As with most college programs, budget cuts have been taken and are seriously affecting the quality of education in my college. We have sustained approximately a 25% reduction in operations budgets, which translates into fewer "hands on" programs and fewer activities for students. Practical application of scientific research is especially imperative in the agricultural curriculum, since this the nature of the science. Graduate student monies have been cut in half so MSU cannot already attract as many top rate grad students as in

the past. Because we have fewer grad students to teach labs and class sections, the number of classes available for students has been sliced. To compound the problem, it has been deemed necessary to eliminate all student labor for further economic savings. Again, the students suffer from a lack "hands on" experience, abnormally large classes and labs, and an overall lack of faith in our College of Ag.

Of course, the College of Ag is not alone with these problems. Virtually every department and program is feeling the budget-cutting axe. Programs and class sections are now commonly being dropped throughout our campus. The morale of students is dropping with their lack of confidence in the Montana University System. We wonder if the credibility of our colleges is still held as highly as it has been.

If these perceptions by students and industry continue to grow, we will continue to see an increase in students leaving the state to further their education and more importantly, to seek career placement. This loss of business and industry can't help but cause a further decline in Montana's economy. By cutting education budgets you will be continuing this vicious cycle.

The quality of education in our Montana University System does not have to be sacrificed or thrown away. Our

students do not have to suffer a lack of faith or credibility in their programs. Students should not have to be asked to settle for lower standards and yet pay higher prices for a questionable education. I ask you today to seriously examine these issues closely and without the callousness of a detached third party. I realize that you will be responsible for molding our colleges' and universities' futures; and I ask that you make a firm commitment to a quality education and give a resounding "no" to further budget cuts and decimation of our people's education.

Testimony of Wade Ayala, MSU Wrestler

Before the Joint Appropriations Subcommittee

of the Montana Legislative Assembly

February 2, 1987

Mr Chairman and members of the committee, my name is Wade Ayala and I'm here to speak to you about the wrestling program at MSU. I've been a wrestler for 14 years, and I've wrestled for MSU for the past 2 years. I am currently ranked number 1 in the NCAA Division I. My success in the wrestling arena has brought me a great deal of personal fulfillment as well as positive attention to the university I represent.

I grew up in Missoula, Montana, and after I graduate with my degree in secondary education, I would like to spend my life teaching and coaching in this state. Why? Because I would like to give something back to the sport that has done so much for me, and because I have a genuine committment to young people. I would like to ask you to make that same committment and recommend that the House Appropriations Committee make Higher Education a high priority.

Athletic programs do what for students? These programs bring feelings of self-esteem, self confidence, and self worth. It also teaches one discipline, which is a valuable tool for later life.

Many people seem to have the perception that college athletes are living on easy street. I can tell you that this

is not true. In fact, most student-athletes have a more difficult time than regular students. Athletes must budget time between training and studying, each of which takes a great deal of dedication. Had it not been for athletics I can say in all honesty that college would have been little more than a dream for me.

Each time I step on the mat, whether it be at the Regional level or the National level, it takes courage. The pressure is so intense, I often don't know if I can overcome the adversity of the situation. I'm sure that you are feeling the same pressure, and I ask you to summon your courage to overcome it. Have courage to overcome this adverse situation and say NO to further budget cuts.

School of Architecture
Owen Letcher
Student
Sub-committee hearing
February 2, 1987

The School of Architecture is a vital part of the Montana University system and of Montana State University. The future of Architecture is in a desperate situation. With the latest round of budget cuts the Architecture program has been slated for elimination. The program, however, must be phased out over a five year period. The phase out period will COST the State and the University money to complete.[1] The money for this phase out will come from other programs on the campus, therefore jeopardizing the quality of education in the other programs.[2]

The School of Architecture is a unique element in the Montana University System. The reputation of the school is one of excellance. This is illustrated by the fact that there are more inquiries from the profession than there are students available to fill those positions.[3] It is a shame to jeopardize a program which has such high standards in these lean financial times. For if we are to fulfill the "BUILD MONTANA" vision then we must have people educated to build that environment.

Because Montana is unique, there is a need to train those responsible for future construction of the state in the state. Although a great number of graduates leave the state after graduation, a great number return after gaining valuable experience which is not available in this state.[4]

Although Architecture is a healthy industry in the state at this time it will not continue this trend. The high school students interested in architecture will not transfer into another program but will take there money out of state to pursue an education. This lack of confidence in higher education is beginning to show now with a larger number of students applying out of state for their continuing education. Recently at Capitol High School all the students who were interested in architecture sent applications out of state instead of sending them to Montana State University.[5]

If the school of Architecture is lost from the state it will not return. I ask that to save the valuable resource that the state has that you support the funding of higher education at the level which would include the continuence of the school of Architecture. Thank you for your time and if you have any questions which I might be able to answer please contact me at the school of Architecture.

School of Architecture
Owen Letcher
Student
Sub-committee hearing
February 2, 1987

[1] As stated to the students by President William Tietz, and verified through Robert Utzinger, Director School of Architecture.

[2] As stated by President William Tietz on January 30, 1987 in meeting with Owen Letcher and Carlene Pederson.

[3] Confermed through Robert Utzinger, Director School of Architecture.

4 Confermed through Robert Utzinger, Director School of Architecture.

5 Confermed through Gary Duff, Instructor Capital High School.

Information Sheet

1. The loss of the school of Architecture would deny many Montanans the opportunity for an education in Architecture.

2. Phasing out the school of Architecture would ultimately cost the University system more money than maintaining the program for at least 5 years. (School of Architecture)

3. Montana would lose "Made in Montana" architecture.

4. To become a licensed architect, a person must not only graduate from an accredited school, that school must remain acccredited for two full years following his or her graduation! (Montana Law)

5. Sixty-two percent of all resident, licensed architects in Montana graduated from Montana State University. (Montana Dept. of Commerce)

6. Architecture classes have been offered at Montana State University since 1913. (M.S.U.)

7. A degree in architecture has been offered at Montana State University since 1924. (M.S.U.)

8. 16% to 20% of the students enrolled in classes at the school of Architecture are from other curriculums. (School of Architecture)

9. Architecture is mentioned twice in the role and scope statement of Montana State University. (M.S.U. Faculity Handbook)

10. The school of Architecture at Montana State University has done a superior job of preparing students for the profession of Architecture. (Montana chapter of American Institue of Architects)

11. The Architural program at Montana State University is the only one (unique) in the state. (School of Architecture)

12. Architecture is just the kind of small technical industry which the Governor and the Legislature have said are needed in this state. (Montana Chapter of American Institute of Architects)

13. The school of Architecture has performed service of great value to the public through its public lecture series, its publications its research projects and its student community projects. (Montana Chapter of American Institute of Architects)

14. The industry of Architecture is an economic force in the state. In the last fiscal year it processed two-hundred million dollars of construction and twenty-four million dollars of taxable income that remained in the state. (Montana Chapter of American Institute of Architects)

15. To remove the architectural school would deal a severe blow to the stability of the industry within the state of Montana. (Montana Chapter of American Institute of Architects)

Compiled by the Montana State University School of Architecture students
Janet Storey

Testimony of Nancy G. Korizek, ASMSU President

Before the Joint Appropriations Subcommittee on Higher Education

Montana Legislative Assembly February 2, 1987

Chairman Nathe and members of the committee. As you can see today these students' words need to be taken to heart. Some have expressed concern about the current situation of a specific program, and some have described possibilities of potencially disasterous effects on programs that are top quality now. These students are only a small representative sample of the 9000 more students at MSU, most of which are Montana kids who have grown up in the state and want to have the chance at obtaining the kind of quality education that their parents received in this state.

Students want to know what is happening in Helena. I do not have the answers for them. I cannot explain why various appointed boards or subcommittees or campuses cannot come up with solutions. In the meantime those people being affected--THE STUDENTS--are the ones being hurt.

The Students of Montana State University are worried right now and they have good reason to be. Gradually, after the end of the third special session, campus awareness regarding the plight of higher education was brought to a level of concern that students haven't shown since the 60's

and early 70's. And for darn good reason too. Some may argue that livelihoods are being threatened, that futures are at stake and that access to edcuational opportunities are being closed. I wouldn't agree with that at all. No, I would say that students are upset because decisions are currently being made (or not made as the case may be) that are nonsensical. Beyond that, students have seen the results of cutbacks in many forms, classes being totally cut out or the size of the class being increased reflecting the decline in teacher/ student ratios, library hours being reduced and student services either being cut out completely or reduced beyond the point of service to the students.

In comparing Montana to other states, we find that Montana does or does not stack up depending on who is doing the comparing. Well, let me do some comparing. In studying other states that have been in the same economic straits that we are in today it becomes evident that every single state that has turned their economic condition around, those states that are balancing their budgets in the black and those states that are prospering, have all invested in their educational system. Every single state that is succeding economically today has invested in their higher educational system not made drastic cuts but invested. States such as

Massachusetts, and Oregon. Where does that leave us? Of course there must be cuts in state spending, of course we must look at revenue enhancement measures, of course every state agency is screaming for more money or minimumlly current funding--this state is hurting. Every possible solution is microscopically being examined yet the university system is being overlooked. We must see our colleges and univerities as aiding in the solution. The five major industries in the state including agriculture, mining, tourism, timber and service industries, can be enhanced, studied, and aided in every aspect with the knowledge, know how and resources at the universities. We must tap into that. We must realize all the potencial that is sitting within the university system in Montana. How can we overlook that? In the tough times this state is facing now and will continue to face in the next couple years cutbacks in higher edcuation will only cripple us that much more, cutbacks will only shut down resources that we cannot do without, cutbacks will create such terrible echo effects in this state that not only will the universities not beable to get back on their feet but the State of Montana will be depriving herself of a resource that is valuable beyond measure.

You people must make some tough decisions. You must have the courage to put an accurate price tag on the

university system in Montana, you must have the courage to do what is best for the state of Montana regardless of external pressures. You must say no to cuts in Montanas past, present and most important resource Montana's future--our educational system.

AMERICAN ASSOCIATION of UNIVERSITY WOMEN

MONTANA DIVISION

1 February 1987

Rep. Dennis Nathe, chairman
Education Subcommittee of the
Appropriations Committee
Helena, MT 59620

Dear Sirs and Madame:

The Division passed the following as a part of its Legislative Program 1986-88 at convention in Butte 3 May 1986:

"The Montana Division of AAUW believing that state government should play a decisive role in determining the social,economic, cultural and physical environment of its people, will support legislation as follows:....

Education

1. Legislation to raise the current levels of state support for:
   A. The public school foundation program.
   B. Adequate funding for gifted student program.
   C. The six-unit University system.
   D. The Community Colleges.
   E. Other post-secondary ed.including vocational.
   F. Montana School for the Deaf and Blind.
2. A. Protection of the basic principles of public funds for public schools.
   B. Maintenance of the current level of funding for special education programs.
3. Educational equity for women.
4. Bias-free opportunities for lifelong learning, including vocational,technical,career,reentry and non-traditional forms of education.
5. Raising the 1% state libraries cut of coal tax.
6. Educational programs suitable for people in restricted environments.(State prison etc)
7. Protection for the pursuit of knowledge and access to information and ideas.
8. Reinforcement of the Board of Education's constitutional right to define a "basic education" and the local school district's autonomy to interpret that policy."

Resolutions passed included support of the 4% increase in the Foundation program, maintenance of the 6-mill levy for the University system, and support of earmarking a percentage of any new or increased taxes for public education and higher education in Montana. Even in these times of revenue shortfall, it seems peculiarly short-sighted to decrease programs which have so benefitted our citizens.

Sincerely,

B.J.Wood, Legislative chairman(state)

Ex 8

Testimony for Educational Subcommittee February 2, 1987

My name is Beatrice Taylor, from Bozeman Montana. I served as President of the Board of Trustees of the Museum of the Rockies for four years and served on the cabinet of the MSU Challenge, an $8 million campaign. During the last four years I have been heavily involved in fund raising for the museum and helped in securing $4.5 million towards our building project. I am currently serving as Campaign Chairman for our $3 million campaign for planetarium equipment and exhibits.

As a fundraiser and a principle donor to the building project, I have expended my efforts in securing funds from private sources to provide a fully equipped new museum building, valued at $9.5 million, to be donated to the State. I have operated on the assumption, stated from years ago, that Montana State University and the state would continue to provide their 1/3 of the operational support as we have had in the past.

I would encourage you to support the program modification in support of the Museum of the Rockies for ~~$220,000 FY 87-88~~ ~~$349,000 FY 88-89~~ without your support, as a fundraiser I would lose credibility in the solicitation of funds, and as a donor I would lose faith in the fact that my investment in the museum — and by extension the university and the state - will be secure and will be maintained in the professional manner I expected when making the financial commitment. ~~The~~ Donations of both time and money will suffer if the future caretaking of museum and the funds are left in jeopardy and indecision.

Dated: February 2, 1987

FOR IMMEDIATE RELEASE

For More information, contact: Janet Storey 587-7712

MSU ARCHITECTURE STUDENTS CHALLENGE ADMINISTRATION CLAIMS OF MONEY SAVINGS

Montana State University president, William Tietz, has claimed elimination of the School of Architecture from the curriculum at MSU would save the university $81,000 next year and over $550,000 annually after the school is phased out. Today, MSU Architecture students released the results of a study challenging Tietz's claim.

MSU Architecture students claim that elimination of their program would actually cost taxpayers money because of the loss of student tuition and the costs of phasing the program out. Tietz claims the University would not lose money because architecture students would transfer to other curriculums and not leave MSU.

The survey of 244 architecture students shows that 77 percent of the students would not remain at MSU if architecture were phased out, as Tietz intends, and 92 percent would leave if the program loses its accreditation. 71 percent of all architecture students at MSU were polled.

If the School of Architecture were eliminated or lost its accreditation effective July 1, 1987 and if 92 percent of the

(more)

students left, MSU would save the program costs of $551,426 but would lose tuition in excess of $383,653, an apparent savings of $167,773. However, architecture students may be eligible for state financial support, WICHE, of $3400 per year if the architecture program were eliminated. 41% of the 244 students surveyed claimed that transferring to an out-of-state university would be financially impossible without support. State WICHE costs for architecture have been minimally estimated at $153,000 per year, reducing the state savings to $14,773. The state would also lose, to other states with architecture schools, the estimated $1.1 million per year the students spend on food, housing, books, supplies and miscellaneous expenses.

However, Tietz has a legal obligation to phase the architecture program out over a 4 year period. Tietz estimated the phase out would cost the University $28,000 during its first year and that other programs would have to be eliminated to pay for the phase out. The School of Architecture estimated their first year phase out costs to be $157,521.

The School of Architecture estimates that over the 4 year phase out the state will lose over $336,000. The students maintain that the phase out costs are far greater than the maximum long term savings of $14,773 per year. The students further maintain that a savings of $14,773 per year does not justify displacing the over 200 students who would leave the state to find their education elsewhere.

February 2, 1987

TESTIMONY FOR
HIGHER EDUCATION

My name is Susan Butler and I am the Public Affairs Chairman for the Montana Home Economics Association.

The Montana Home Economics Association unamiously supports increased funding for higher education.

For the past several years the Universities along with other state agencies have been absorbing massive budget reductions. There is a limit to how much you can cut without totally destroying the quality programs that exist at Montana State University. If we can't support higher education, than the future of Montana is bleak!

There is still time to change the drastic reductions you are imposing on the University system, in doing so, I urge you to develop a tax structure that will support higher education.

2-2-87

Mr. Chairman and members of the committee:

My name is Erica Cantrell. I am a senior from Laurel High School. I am here to represent my peers from around the state.

In a time when you are attempting to draw more high school graduates to Montana's colleges, I have some sobering statistics for you. Out of my class of 116 students, 40% of them intend to pursue a higher education. 17% plan to stay in-state. Approximately 25% of my peers are undecided in their plans, and their futures rest ~~upon~~ largely upon the developing status of our state's college & university system. These figures are not only indicitive of Laurel High School, but also reflect an unhappy trend around Montana.

We are all making decisions about our future, and that often brings conflict. We want to stay in Montana, where our family and friends and hearts are. But we also want the best education we can get. It is your job to try and combine these two options.

As you make decisions in the following days and months, I ask you to keep the 25% "undecided" foremost in your minds.

This is the group that will be the deciding factor for Montana's universities in the years to come. Several legitimate thoughts have been voiced. Ranking high among these is the concern about which programs will be eliminated from the schools. It would be a grave mistake to do away with "unique" studies; if ~~Seat~~ pharmacy and Scandinavian studies are cut, for instance, would-be students of Montana universities will be forced to go out of state.

I myself will be attending Arizona State University instead of University of Montana for one main reason: lack of stability in Montana schools. I love Montana and would love to spend my life here, but my education means to much to gamble on. I, and many like me, refused to be hit during our junior year with the realization that our majors no longer exist.

As you try to sort out our situation, remember that ~~High school stud~~ thousands of high school students are following your choices closely. What you decide to do will change lives. For some, it means the difference between trying to make something of themselves or just settling for the bands they are in. I leave you with a quote from one Laurel High School senior: "If funding is cut and courses are dropped from Montana's colleges, I will have no chance for a rewarding life - long career."

Thank you.

VISITOR'S REGISTER

Education SUBCOMMITTEE

AGENCY(S) MSU DATE 2-2-87

DEPARTMENT

NAME	REPRESENTING	SUPPORT	OPPOSE
CARROL KRAUSE	Com. of H. ED	X	
Craig Roloff	MSU	X	
Pat Rooney			
Darrell Kurtz	MSU	X	
Bill Tietz	MSU	X	
Erica Canthrell	Laurel H.S.	X	
Jim Isch	MSU	X	
Loren W. Acton	Self & Future of State	X	
David Maloney	SELF Parents of Students	X	
Ed Wood	CAUW	X	
David S. Davidson	Practicing Architect		
Wade R. Hyatt	MSU	X	
Orvis L Loftfon	MSU		
Michael W Hager	MSU	X	
Merrill Cummings	MSUIA	X	
Norma G. Henderson	MPEA	X	
Lloyd Allen	Yellowstone Int.	X	
Bertha Taylor	MSU - Museum	X	
Bill Rankin	MSU College of Ag.	X	

IF YOU CARE TO WRITE COMMENTS, ASK SECRETARY FOR WITNESS STATEMENT.
IF YOU HAVE WRITTEN COMMENTS, PLEASE GIVE A COPY TO THE SECRETARY.

FORM CS-33A
Rev. 1985