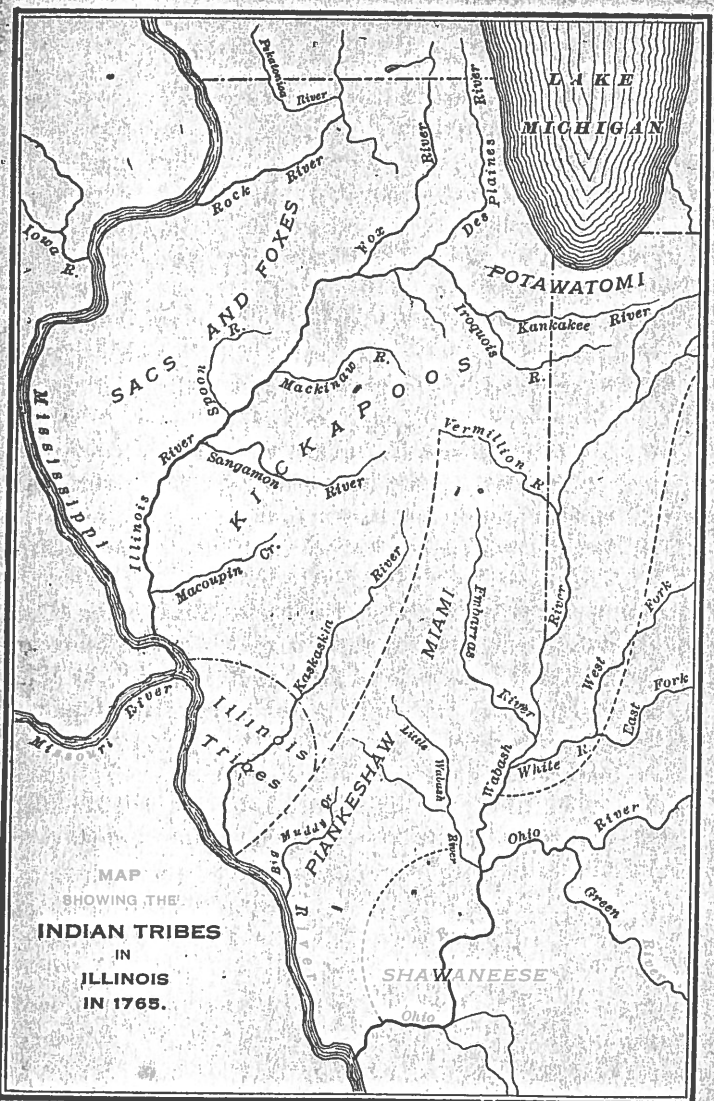


MAP SHOWING THE INDIAN TRIBES IN ILLINOIS IN 1765.

CHAPTER II.

THE INDIAN.

When first explored, Illinois, like other portions of our country, was inhabited by the red men. How many years they had dwelt here or what peoples they displaced, we do not know. There are historians who believe that they were preceded by another race, who built beautiful palaces and large cities which long ago crumbled into dust. Others suppose that mounds, and various evidences of an earlier occupation of the territory, were the works of the ancestors of the Indian.

When the Europeans discovered America they found the Indians living in small villages or scattered in roving bands. Indians east of the Mississippi River have been classified in groups, each embracing several tribes more or less connected by ties of blood, and these groups placed in three general divisions: the Muskhogees, who lived south of the Tennessee River and comprised the Choctaw, the Chickasaw, Creek and Seminole tribes; the Iroquois, who occupied the territory extending from the Hudson and Delaware Rivers westward to the Great Lakes and north to the St. Lawrence. These warlike people included the famous five Nations of New York,—Mohawk, Oneida, Onondaga, Cayuga and Seneca, and also the Cherokees, Hurons, Eries and the Tuscaroras.

And finally the powerful Algonquin family, who occupied the remaining territory east of the Mississippi River.

CULTURE

The Great Hall of Bacteria

The Smithsonian rewrites natural history with some long-neglected characters

JOHN TROHA—BLACK STAR

Other cultures through Western eyes: *Europe meets the Indians in a museum diorama*

Sometime during the Eisenhower administration they were sealed in a glass case at the Smithsonian's National Museum of Natural History in Washington, D.C., five lions stuffed and mounted in a tableau that perfectly recreates the iconography of that remote and fabled era. "Lionesses" (a term for female lions, contemporaneous with "ladies") slump passively on their little slab of habitat, while the male of the species stands erect on a rock, sizing up a herd of zebras galloping over the background scrim. As the nearby text makes clear, zoologists even then knew perfectly well that the male wouldn't ordinarily bestir himself to chase his own dinner. But the modelmakers couldn't bring themselves to portray the females as hunters; it would have seemed so . . . unnatural.

Yet how wrong this tableau seems now, in an era when you wouldn't dare use the phrase "King of Beasts" around a female lion, or she'd eat you alive. In case it *doesn't* seem wrong to you, the museum recently provided a sign to inoculate unwary visitors against the sexist implications of this display, pointing out the contradictions between the text and the diorama. This "dilemma label" is the work of the Natural History's new associate director for public programs, Robert Sullivan. Sullivan, 43, took office in 1990 with an agenda to bring the "Museum of Man" (as it is still called on a plaque near the entrance) into the multicultural, gender-neutral, ecologically aware present. To achieve it, he will need to change half of the museum's 140,000 square feet of exhibit space by 1997.

Even a quick tour down the halls shows how much work lies ahead. The label next to the passenger pigeon attributes its extinction to "the avarice and thoughtlessness of man," completely overlooking the role of *woman* in the extermination of the passenger pigeon. Here is the moose: "In this early autumn scene the large bull seems to challenge the younger male at the left. The cow moose in the center is accompanied by a yearling calf . . ." The dominant animal in almost all of the big mammal dioramas is the male—although, to be fair, as Carolyn Margolis, chief of exhibit development, points out, the ones with horns "are usually the more attractive and dramatic animals."

But Sullivan thinks the museum devotes far too much space anyway to large terrestrial mammals, the group to which people happen to belong. This bias reinforces humanity's tendency to see itself at the center of creation, which doesn't need any encouragement. ". . . [O]ften clownlike in its actions," the label says of the black bear, "sometimes annoying but seldom dangerous to man, [it] has added much to the lore of American pioneer life." What more could one possibly need to know about an animal? Perhaps this: that bears, or even the museum's famous bull elephant, frozen in midbellow at the center of its immense rotunda, are just epiphenomena of an ecosystem embracing organisms from the subslime to the ridiculous. But there are no Great Halls of Bacteria in our museums. Yet.

Ritual scars: As with the animal kingdom . . . errr, *realm,* so does the museum deal with all peoples other than Western. They are viewed through Western eyes, as colorful bearers of spears and masks and practitioners of ritual scarring and cannibalism. In one diorama that Sullivan hopes to remove, bare-breasted Indian women gaze up adoringly at Capt. John Smith trading on the James River in the early 17th century. The hall of Africa, which stops just short of calling its subject the Dark Continent, has been closed by Sullivan for a yearlong renovation. The new exhibit will inform visitors that Africa now contains cities as well as villages and will house a section devoted to the African diaspora. Gone will be the display of pipes labeled "Tobacco and Hemp in West and Central Africa" (". . . smoking is common among most Africans south of the Sahara . . .") and the wall of bloodcurdling "Weapons of Central Africa" ("Large elaborately shaped knives were used to behead sacrificial victims . . .").

Is this, as some critics have suggested, just bowing to the fashion for multiculturalism, also known as political correctness? Well, imagine walking into a museum in Africa and finding a display of "Weapons of America" ("Automatic rifles were used to massacre schoolchildren . . ."). Sullivan is attacking the basic assumptions of a "museum of natural history," a colonnaded temple of Western civilization into which we put examples of all other cultures and species. "The museum says to other groups, 'We will determine what your identity will be'," Sullivan says. It "sought out the most exotic behavior in other societies in order to demonstrate our distance from them. But the world has changed. We can no longer be a colonial institution in a postcolonial world."

JERRY ADLER *in Washington*

ENVIRONMENT

Danger: No Sharks!

The kings of the high seas are floundering

After weeks of scut work the Earthwatch volunteers were ready for their reward. Equipped with snorkeling gear, they dived into the clear waters off Bimini and hovered at the surface awaiting their guests. A researcher swam to the rocky bottom 15 feet below and anchored a bucket of dead fish. The snorkelers gasped through their tiny air tubes as the first six-foot-long, battleship-gray creature arrived. Others followed, moving gracefully past the humans toward their prey. These were not man-eaters or monsters but Caribbean Reef sharks, and they were awesomely beautiful. "Imagine if your kid could see that," University of Miami shark expert Samuel Gruber says later onshore. "Imagine if he couldn't."

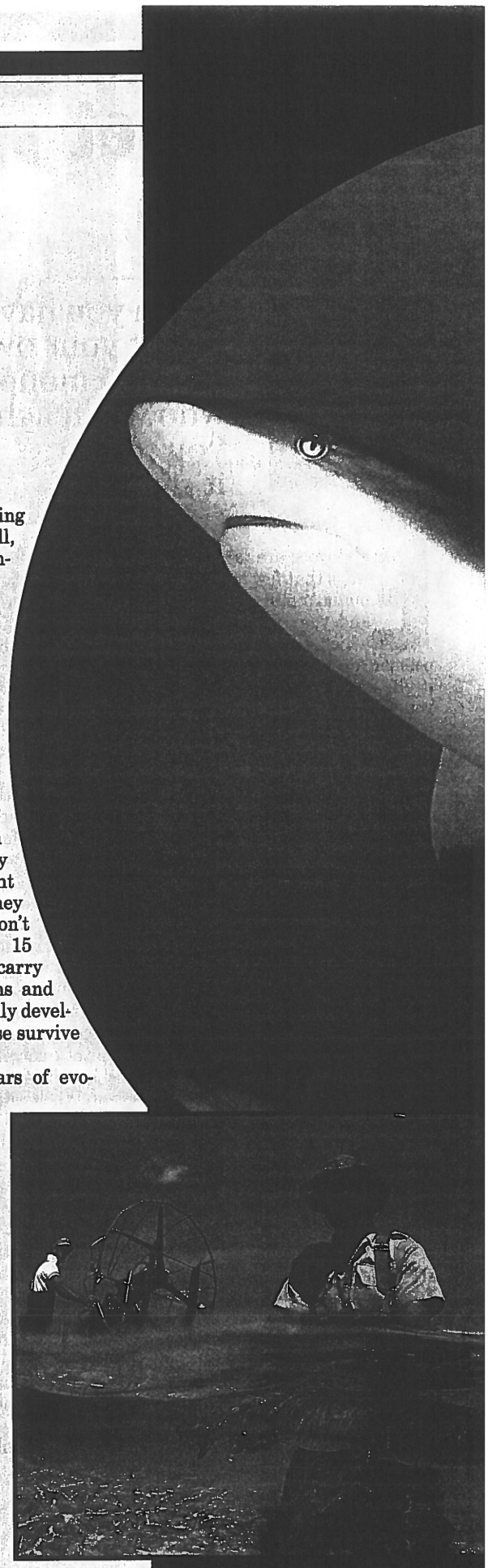
It took millions of years of evolutionary honing for the shark to become king of the seas: the predator at the head of the aquatic food chain. And it's taken only about 10 years more for the shark to be overmatched by the most deadly killer on earth—man. Each year tens of millions of sharks are killed worldwide for food, for sport and by accident, caught in nets intended for shrimp, swordfish or tuna. (Sharks caught in nets cast for other fish are often clubbed to death aboard ship and tossed back.) So many are dying so rapidly that shark men like Gruber fear for the future of these species. Indeed, a coalition of environmental groups and fisheries scientists has been pressing a shark-saving plan on the U.S. Commerce Department since 1989. The Bush administration has never acted on the issue. If there is no plan by next month, shark enthusiasts may go to court or look to the "green" Clinton-Gore administration.

Selling the shark's cause is not easy. Sharks are generally portrayed as mindless killing machines, more like the Saddam Husseins of the natural world than the kinds of animals that inspire films like "Born Free." But just like lions or tigers, sharks are important predators and scavengers pruning weak and dying animals from their habitat. Still, few children fall asleep clutching a stuffed, saber-toothed fish. But must we kill what we haven't learned to love?

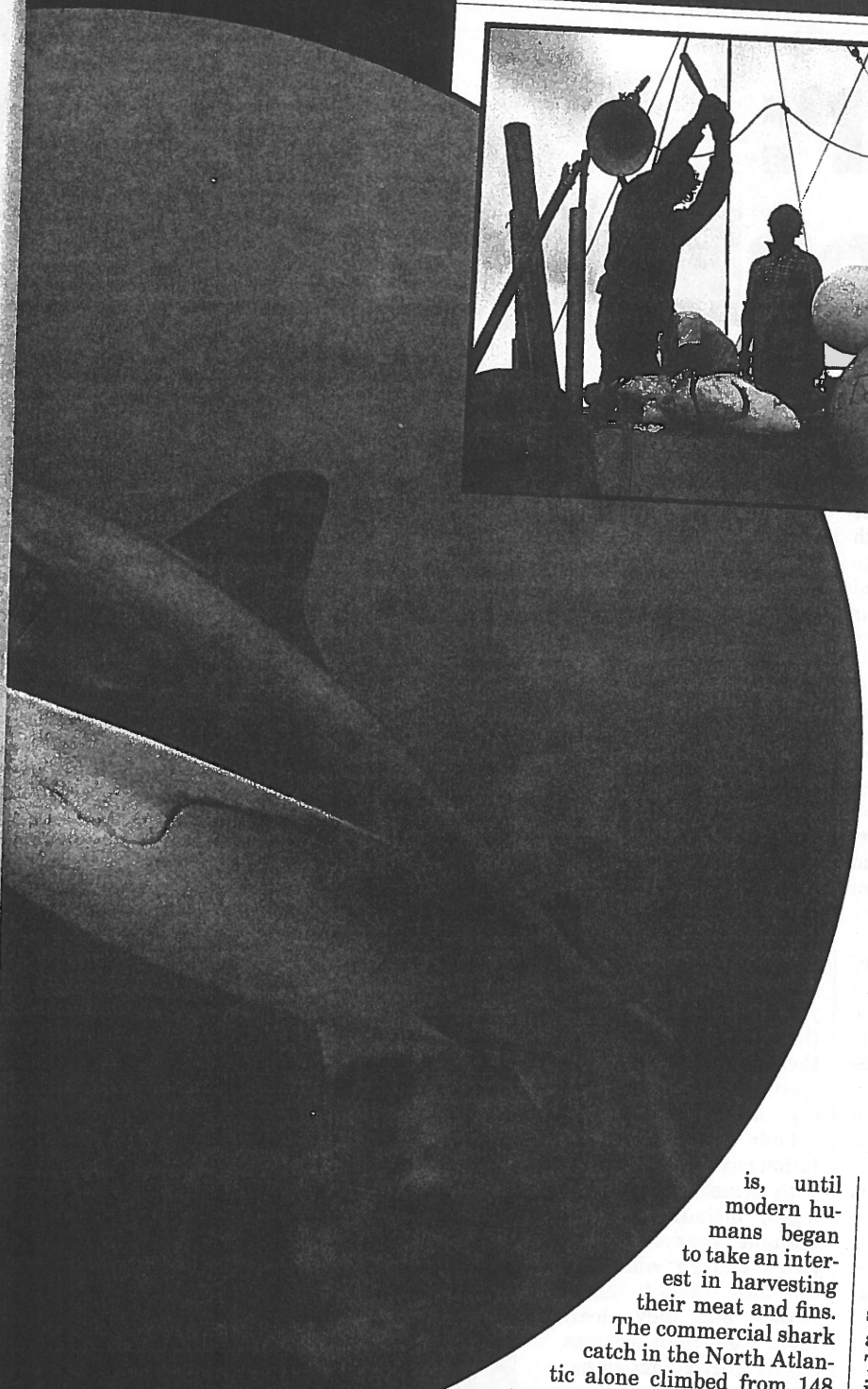
Thanks to "Jaws" I to IV, the great white is the most famous shark, but it's not the biggest. The whale shark is roughly as long as a tractor-trailer but eats only the small fish and plankton it filters from the water. In all, there are more than 350 species of sharks, some as small as a trout. Gruber works mostly with lemon sharks (about eight feet long and 350 pounds). They tend to grow slowly and don't reach sexual maturity for 15 years. Mother lemon sharks carry their offspring for 12 months and then give birth to about 10 fully developed babies. Only half of these survive their first year.

Four hundred million years of evolution have endowed sharks with some mighty advantages, including a super immune system. "We injected enough vibrio cholera into them to kill 10 horses, and they cleared them from their systems," says Gruber. Scientists have also been amazed at the extremely low incidence of tumors among sharks—something that may prove to be valuable in cancer research. In other experiments, Gruber's subjects were taught to swim mazes and retained the information for almost a year.

Such skills have allowed sharks to reign over the oceans for millennia—that



CLOCKWISE FROM RIGHT: DAVID DOUBILET, STEPHEN FRINK—THE WATERHOUSE, BOB SLOAN



rep troubles: A Caribbean ef shark (center), Gruber and non shark off Bimini (left), a rowman clubs an accidental tch in the Pacific

is, until modern humans began to take an interest in harvesting their meat and fins. The commercial shark catch in the North Atlantic alone climbed from 148 tons in 1979 to more than 7,000 tons in 1989. It has decreased ever since—a sign that too many sharks are being taken from the sea. That figure doesn't include the accidental catch, which is just as big a haul. "Many of these species were in decline before the commercial-fishing industry took off," says Steve Branstetter, supervisor of the Virginia Institute of Marine Science's shark project. "That was just the straw that broke the camel's back."

Backs—technically dorsals—are just what are being broken. The shark's comes equipped with a fin that has become one of its fatal attractions. Throughout Asia, shark-fin soup is enormously popular. The harvesting of the fins, known as finning, is very cruel. Ship crews snare a shark, cut off its fin, then toss the squirming fish back into the ocean. Unable to maneuver, the shark is left to sink and die. Shark meat has also drawn attention from chefs seeking a low-priced substitute for scallops. Armed with a sharpened cookie cutter, a clever fishmonger can turn a dead shark into thousands of succulent, and perfectly round, scallops. They're cheaper, firmer and about as tasty when cooked with oil and garlic.

'Black hole': Since 1989 biologists have been asking the secretary of commerce to develop a plan to manage the declining North Atlantic shark population. These rules of engagement would set limits on how many sharks could be taken per boat and restrict finning. Drafts have since gone through at least two revisions and enough public hearings to sink a trawler. But, says Tom Hoff of the Mid-Atlantic Fishery Management Council, "it fell into the black hole in Washington. It really has been tied up with bureaucracy and politics." He speculates that strong lobbying efforts by the fishing industry combined with the deregulation ethic of the Reagan and Bush eras thwarted the conservation efforts. Bill Fox, director of the National Marine Fisheries Service, denies that political pressure had an effect, but he does acknowledge a certain amount of frustration with the approval process. "Fisheries management in the U.S. is a complex process that takes much too long," he says. Last month the NMFS announced yet another delay in publishing a final plan. Fox hopes to have a final version by mid-January.

Back in the waters off Bimini, Gruber stands inside a holding pen cradling a two-foot-long juvenile lemon shark upside down in his hands. The shark is in a sleep-like trance after Gruber's expert manipulations. A doctoral student makes a small cut in the animal's belly to insert a Tootsie Roll-size tracking transmitter. Thunder rolls in the distance and lightning illuminates approaching storm clouds. As the wind picks up, Gruber orders most of the team ashore, leaving behind only a small group to shine lights on the outdoor operating theater. A final stitch closes the incision enough to last until the morning and better weather. The team hurries in just ahead of the rain. "There's not a lot of people in their right minds who would stand out there with lightning and thunder and operate on sharks," he says later. "I consider it a war on ignorance." A war that Gruber and other shark lovers stand a very real chance of losing.

VERNON CHURCH *in Bimini*

"Riffles & Eddies"

Melvin Monsen, President
Jeb Wright, Secretary
Richard Kahler, Treasurer

Jim Turner, Trustee
Allan Johnson, Trustee
Audrey Friend, Executive Director

VOL. XVI-NO. 6 NOVEMBER/DECEMBER 1992

What Native Americans lived in Pawnee Oregon

CARETAKERS OF THE LAND

The Boone County Conservation District hosted the 20th Anniversary of the Illinois Association of conservation Districts on October 23 and 24.

Representatives were present from the following Districts: Macon County, Vermilion County, McHenry County, Putnam County and from the Department of Conservation, Springfield.

Friday evening made a lasting impression on everyone and will be remembered always in everyone's mind who partook in the evening.

The theme of the evening was entitled "Caretakers of the Land."

Funk and Wagnalls Standard College Dictionary describes a caretaker as one who takes care of a place, or person; a custodian.

In the Administration Center, the gathering of persons were told that in the beginning with a concern for the fate of the old Rainbow Gardens ...e just east of Belvidere, the Belvidere Jaycees ...egan a search for ways of using the site as a wayside park. Upon investigation, by Jaycee member Attorney David Babb, a then newly passed law, the Illinois Conservation District Act, was found to be the best possible method to insure a future park and open space system for the entire county.

A brief but furious campaign complete with campaign buttons saw the November 4, 1964 election passing the required referendum to establish the first Conservation District in Illinois.

Although the first organizational meeting of the Board of Trustees was held in January 1965, understandably organizational concerns consumed most of the next several months meetings.

George Fell of Rockford, the "father" of the Illinois Conservation District Act was called upon to assist in organizing and providing direction for the new district. As Director of the non-profit Natural Land Institute (a local nature conservancy type of organization), Mr. Fell agreed to have the Institute absorb the district's operating expenses for several months until the district was able to financially operate on its own, then repay the institute.

Since the humble beginnings, the District has grown to encompass over 1400 acres of open space, has developed three park areas, has preserved two natural prairie areas, has over fifteen miles of hiking and cross country ski trails, 15+ miles of bicycle trail of which 6 ½ miles is completed, have provided numerous special events and programs and has produced a new Administration/Maintenance Complex.

The prime purpose of a Conservation District is to acquire land for future park and open space use while at the same time preserving a large portion of the natural flora and fauna.

The first acquisition was the Old Fairgrounds, now known as Spencer Park. Being a Boone County-ite, grateful/thankful is a very small word to say to those people who had the foresight to preserve this beautiful area for future generations to enjoy. Many of you, no doubt, have fond memories of this special area that was known as the Old Fairgrounds. Just sit back and visualize the circle road being the race track, the viewing stand across from the grandstand on the North with all the horse/cattle barns and needless to say all the other activities of the day. The center of the Pavilion where the round serving table is located was always arranged beautifully with flowers from Lundins and the story could go on and on.

After the group listened to the history and purpose of the Conservation District, they were led to the wigwam and visited by the granddaughter of Nokomis who told her story.

"Boozhoo Nigi!" I bring you greeting from the grandmother - Nokomis. Her people walked this land for many generations. They paddled the Kishwaukee away, and back again. They are the Otowatomie of the Anishinabe. A people strong and proud for they are the Keepers of the Fire."

"Earth is the mother, she gives all life. She has been good to the people. All that is needed for the Otowatomie to live - Mother Earth has given. Our mother has filled this land with beauty. The birds that sing; the plants that bloom, the trees that reach to the sky; these are all gifts."

"The four leggeds who walk on this land are our brothers. They run in the woods and play in the streams. From the four leggeds we learn many things. Which paths are best to travel, which plants are ready to eat."

"All of life is a great circle, from the time of rest in the winter, to the time of new birth in the

Don't Miss the B.C.C.D. Annual Christmas Open House

November 27 - 8:00 a.m. to 8:00 p.m.
November 28 - 9:00 a.m. to 3:00 p.m.

Hundreds of Nature Oriented Gifts!
Come by for some hot cider, cookies and browse awhile.

B.C.C.D. Administration Center
7600 Appleton Road
Belvidere, Illinois

B.C.C.D.11/5/92 3M

Boone County Conservation District
Riffles & Eddies
7600 Appleton Road
Belvidere, Illinois 61008
815-547-7935

Non-Profit
Bulk Rate
U.S. Postage
PAID
Belvidere, IL
Permit No. 31

Happy Holidays to All from the B.C.C.D. Staff

LUTHERAN
OUTDOOR
MINISTRIES
CENTER

December 1, 1992

Hope Ryden
345 East 81st Street
New York, NY 10028

Dear Hope,

I am the Executive Director of Lutheran Outdoor Ministries Center, a 650 acre facility 2.5 miles south of Oregon, Illinois where the ELCA Synods in Illinois do summer camping, outdoor education, and year round weekend retreats. LOMC is the successor to Camps Augustana and Alpine, with which you may be familiar.

I am a graduate of Augustana College and Seminary. I have known several members of your family throughout the years. We have met once at Augustana some years ago. I believe you know my brother-in-law, Bruce Gunnerson.

For each summer, I prepare a resource for the camping program. I try to tackle some of the traditional themes, but put them into a perspective in which the learning can be done outside in terms of ecological studies and the Biblical tradition.

Beside a summer camping program going on at this site we also do camps elsewhere: the Ozarks, Carbondale, Illinois, etc. We are also doing day camps from Decatur to Deerfield. This next year we will be doing eight weeks of day camp in the city of Chicago. Thus, the materials I prepare must be able to fit into these many types of situations.

This next summer I want to address the Third Article of the Apostles' Creed, animals, and Native American spirituality. For some reason I have become fascinated with the coyote. (Now maybe you have an idea of where I am going). There are two reasons for this: first, it is suspected that there are coyotes on our site. Evidence has not been as clear as we would like. We have found several fallen deer. People in the neighborhood think they have spotted them. We are not sure, but there is certainly a possibility of their presence. The second reason is more compelling to me. As I have been reading Native American stories and about their spirituality, I find the coyote perceived in a variety of ways: a trickster, a messenger of God, a teacher, sometimes a more than mischievous animal, a fool and for sure, God's dog. I have appreciated your description of the coyote in your book, and I find myself drawn into the coyote's mystique.

LUTHERAN OUTDOOR MINISTRIES CENTER, P.O. BOX 239, OREGON, ILLINOIS 61061 815-732-2220

The tentative title for the resource for the summer of 1993 is:

"The IKCEYA* AND THE WAKAN** OF THE COYOTE
practicing the Spirit in the *ordinary and **mystery"

Each day we would look at a specific animal, learn about its traits, read Native American stories about the specific animal, and then relate all of this to our practice of the Holy Spirit.

Some of our learning about the practice will be tied in with the Native American sprirtuality - their practice of the presence of the Mysterious One and their ecological sensitivity.

Why should I be writing to you? My wife suggested it. Also it may be that something like this might interest you and especially as I develop this theme.

The arena in which I have been trying to work for several years, and hopefully make a contribution, is the interfacing of theology and ecology and the things that emerge from the dialogue.

If you find this interesting, I would appreciate a short response.

Thanks for listening.

Peace,

Jack Swanson

Consumer/

New Now?

Categories	Nat Am Spirituality	Technological American Spirituality	Historic Am Spirituality	Eco-Spirituality
Object of worship	Native American Spirituality	~~Consumer~~/Technology Techno/Consumer Spirituality	Historic Am Spirituality	EVANGEL/ECO SPIRITUALITY SACRIFICIAL Eco/Evangelical Spirituality
Style of worship				
Symbols	What is spiritual? What is material? Death Life Knowledge Science Time Mode of worship Symbols Space	Mystery Ordinary		
Stories	Justice/Righteousness Natural World Peace Success/Failure Community			
One is absorbed with...				
Interacting w/...				
Time				

John Buffalo Robe Damien
301 Third Avenue S.W.
Jamestown, North Dakota 58401
(701) 251-1130

November 20, 1992

Jack Swanson
Lutheran Outdoor Ministries Center
Box 239
Oregon, Illinois 61061

Jack,

Thanks for your recent call in response to my letter on Native American camp programs. I hope you enjoyed sunny California.

Your planned emphasis on the Holy Spirit in 1993 sounds like an excellent idea, especially the inclusion of traditional Native American spirituality as a model, and concerns for our environment.

After we talked about the possible use of the image of the coyote in your program, I remembered something I'd like to share with you. In many traditional teachings the coyote is seen as a master teacher, which would fit well into the theme of learning at camp. However, if you wanted to consider using the coyote, you should also know that the coyote is often presented in legends and stories as the trickster - the one who teaches humans unforgettable lessons by guile, craftiness, and just plain funny stunts.

I look forward to hearing from you and commenting on your program outline. If you want, I'll also send you a bibliography of useful books on Native Americans culture, crafts, history, and society.

Until then, God bless.

Sincerely,

John Buffalo Robe Damien

John Buffalo Robe Damien
301 Third Avenue S.W.
Jamestown, N.D.
58401

(701) 251-1130

Rev. John Swanson
Lutheran Outdoors Ministries Center
Box 239
Oregon, Illinois
61061

John,

Don Johnson of Camp Calumet and I were talking recently about some of the better outdoor ministries in the U.S., and he suggested I write you.

As you likely know, our Church has named 1992 the year of the Indian. I can help you and your center guests build bridges towards better understanding of Native cultures during this season of "Remembrance, Repentance and Renewal" and throughout 1993.

I offer youth and adults a hands-on approach to learning that combines the unique blend of a solid Lutheran ministry with nearly 14 years of involvement with Native Americans. I engage them in making Indian-style crafts, dancing to powwow music, and telling legends around a campfire. We also have lively discussions on traditional Native spirituality, culture, and sacred ceremonies; and how they mesh with or differ from historic Christianity.

Many parents and youngsters I met with this past year, most recently those at Camp Calumet in New Hampshire, said they had a fun time learning while experiencing an excitingly different culture.

For your consideration, I've included my personal profile sheet and a list of center topics with this letter. I ask for $175 for a day's activities, plus travel and lodging. Extra days of activities are less, and the final cost is negotiable within your budget limits.

If you have any questions, please feel free to call or write. Until then, God bless.

Sincerely,

John Buffalo Robe Damien

John Buffalo Robe Damien

John Buffalo Robe Damien
301 Third Avenue S.W.
Jamestown, North Dakota
58401

(701) 251-1130

- PROFILE -

I am an adopted member of the Red Eagle Clan of Mexico. My Indian name, given me by Wampanoag elders of Massachusetts, is Buffalo Robe.

I was born in the California desert community of Indio, which is Spanish for "Indian". My mother is of German-Lutheran descent, but I don't yet know my father's heritage. He was adopted as an infant, never told who his people were, and died when I was a child. A relative thinks he may have come from one of the local Indian tribes, and I hope to soon document his bloodline.

In the search for my lost heritage, I have been drawn to Native American spirituality and culture.

Upon graduating from Trinity Lutheran Seminary (ELCA), I served a white congregation on the Fort Totten Sioux Indian Reservation in North Dakota. Four years later I launched out on a dual-track career as a supply minister and a photojournalist, winning national and state media awards.

After a move to New England, I produced a television show on Native dancing and became increasingly involved with social gatherings and sacred ceremonies, including sweat lodges, four-color ceremonies, and Sun Dances.

I am now available as a preacher and workshop leader to camps, churches, schools, and conventions across the nation on building bridges of understanding and cultural exchange with Native Americans.

John Buffalo Robe Damien
301 Third Avenue S.W.
Jamestown, North Dakota
58401

(701) 251-1130

- TOPICS -

CRAFTS

- The traditional Indian regalia of deer skins, eagle feathers, and buffalo bones is often a revelation of visions, tribal status, or a military society. We will handle such items as feather headpieces, dance rattles, tobacco pouches, and talking sticks, and can make Indian-style crafts and jewelry.

DANCING AND DRUMMING

- Dramatic and increasingly popular powwows are more than just tourist attractions. These colorful events are a vital link in an unfolding cultural drama that sustains tribal identity and strengthens the bonds of Indian family and friendship. We will see a powwow film, hear authentic Indian drum songs, and join in a traditional Native social dance.

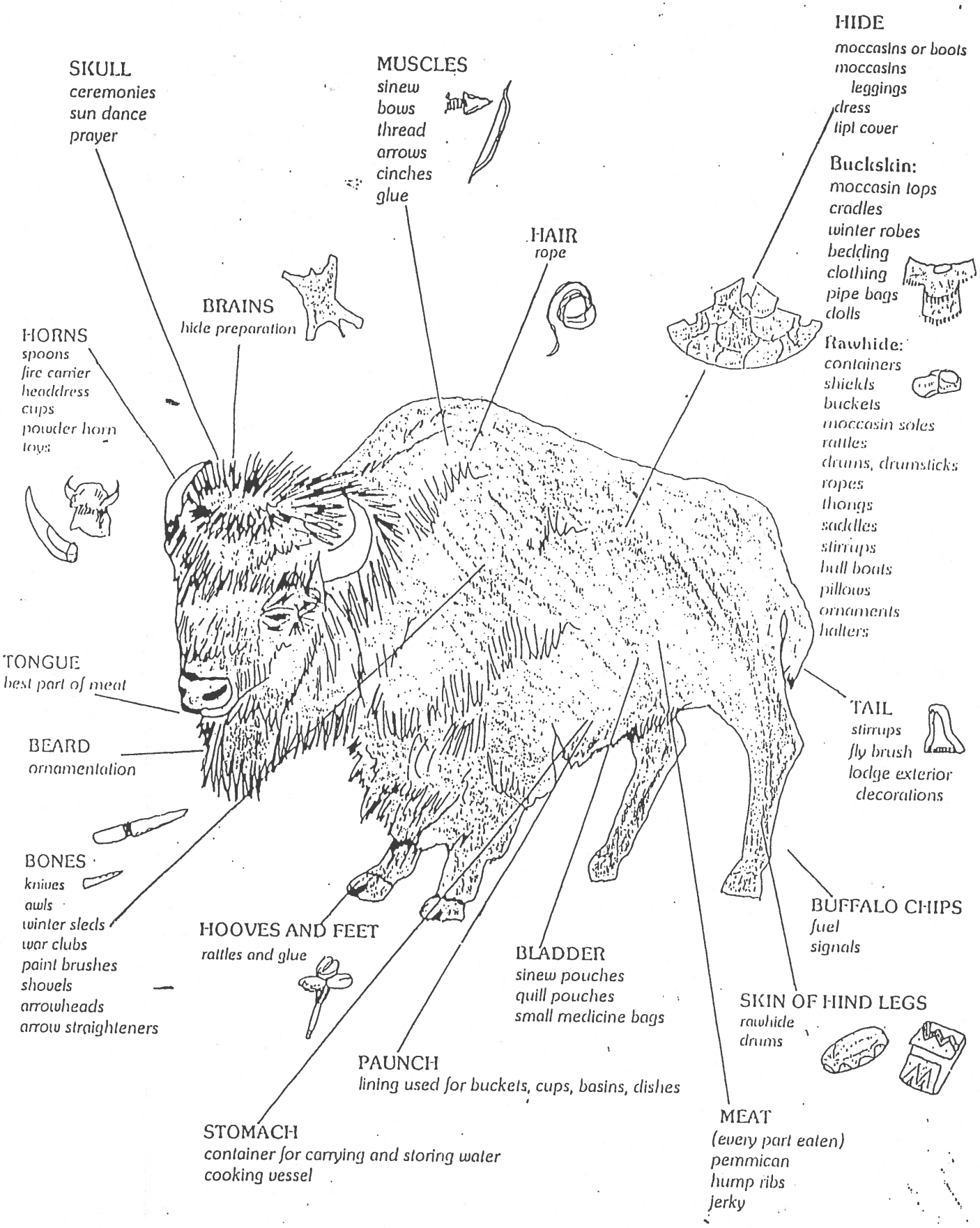
NATIVE SPIRITUALITY

- Traditional Indian spirituality as expressed in creation, ceremonies, and the human heart. Indian people often hold that the Creator is vitally alive in all the earth, that humans are meant to find a sacred path through life, and that such personal quests are ultimately for the good of the people and for the harmony of all creation. During our exploration of Native spirituality, we can use such ceremonial items as sage, tobacco, and sweet grass.

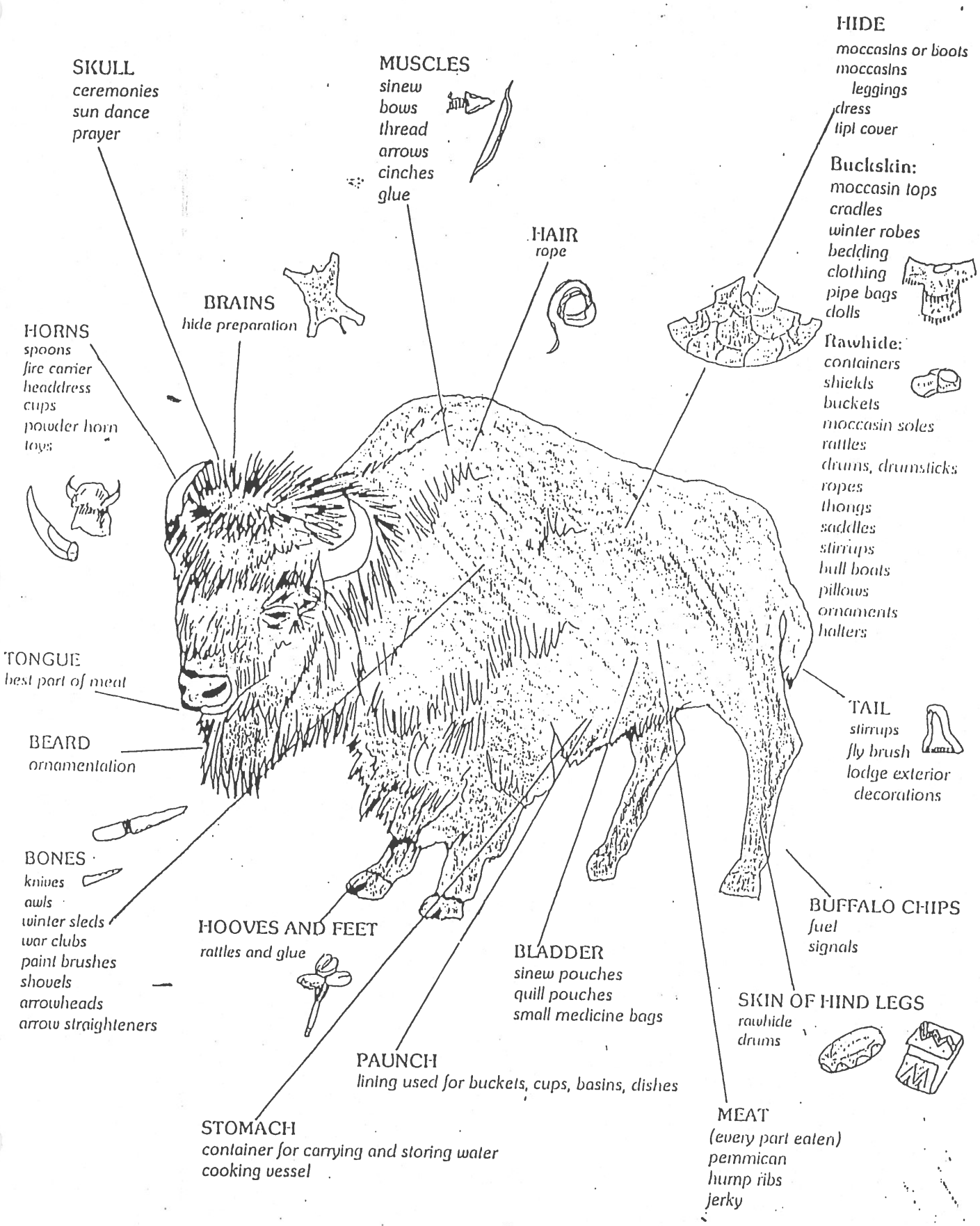
REMEMBRANCE, REPENTANCE, AND RENEWAL

- One topic that encompasses all the above, and more. The tragic and triumphant story of the Indian peoples, from the clash of cultures in 1492, to 500 years of Native struggles for home, culture and identity. A chance to better understand the involvement of churches in the "civilizing" of the Indian and what people of the White and Red nations can do today to make the next 500 years something to celebrate.

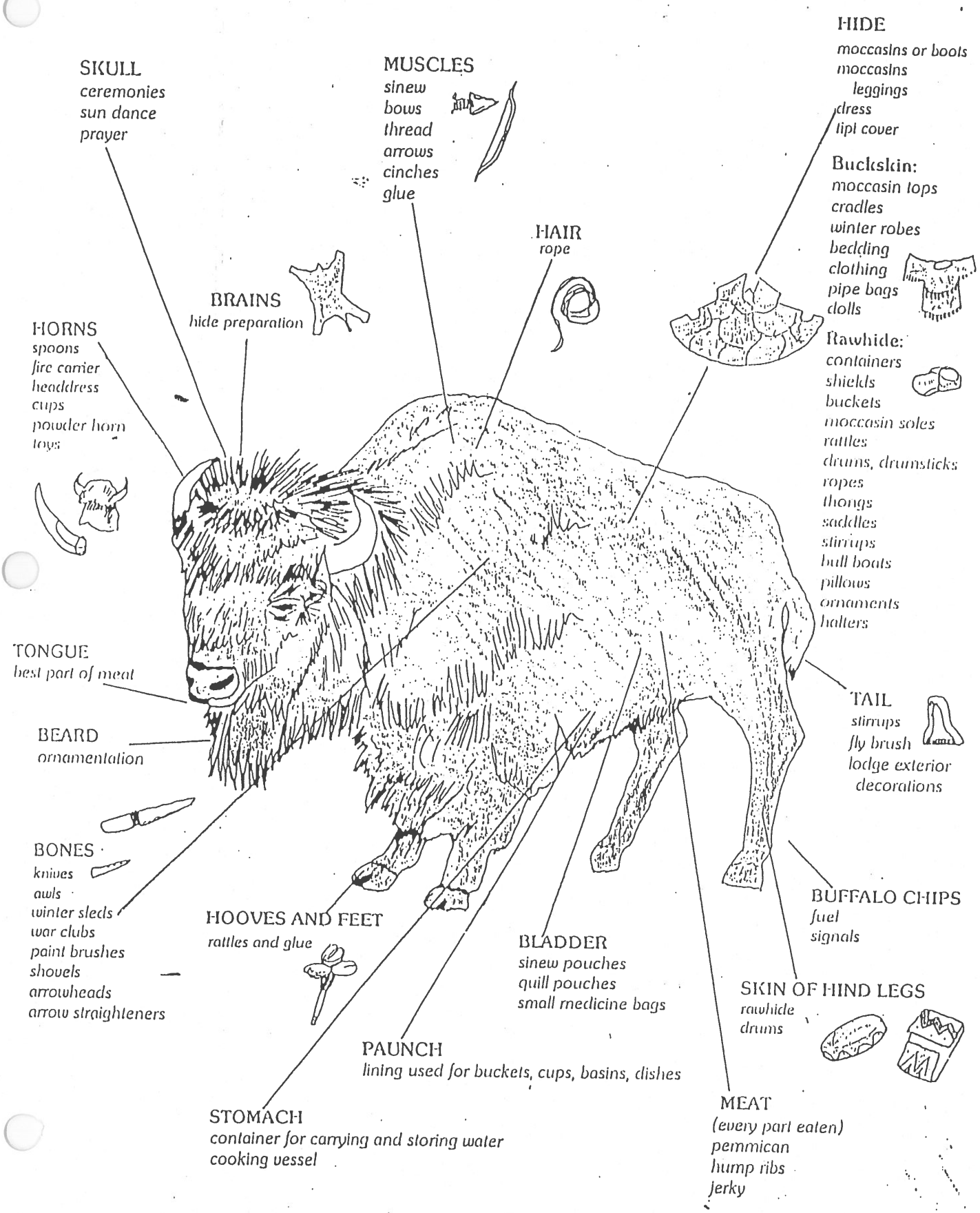
USES OF THE BUFFALO



USES OF THE BUFFALO



USES OF THE BUFFALO



THESE MATERIALS ARE PREPARED

FOR DAY CAMP

GRADES ONE THROUGH THREE

file: 93RES$DAYCAMP$INTRO
revised: 6/14/93

DAY 1

Materials

MESSAGE: Like air that is all around us and fills us so we can breathe, God (the Spirit) is all around us and in us to make us live.

I. Get Acquainted
   A. With people -
      1. Learn the names: a process so each person knows the name of everyone else.
      2. Ask children to name their favorite animal and tell what they know about their favorite animal.
   B. With the place -
      Hike around the place where you meet. Go inside and outside. Look for the existence of any and all animals. The leader will want to keep a list of the things the children discover. What is some of the evidence of animals? Chances are there will be the realization that there are more animals than one ever suspected.

II. Morning Prayer
   A. Find a place for prayer.
      Be intentional about the location. Maybe the children can select it. This might be a select place where you go to pray each day and several times during the day. It is good to talk about why such a place would be selected. What kind of meaning does this place have?
   B. Prayer Content:
      1. Think of all the critters talked about and how they are all around us.
      2. Thank God that God is also around us, everywhere we look. God is there even when God is not seen. Then we call God "Spirit."

III. Games
   A. Balance Games
   B. Animal Games
      1. Noises
      2. Movements
   C. Cooperation Games
   D. Camera Kids — Paper and pencil
   E. Other games
      1. Hug Tag
      2. Pantomime This Object
      3. Two Person Mirroring
      4. Dox-en-eye

IV. Songs
   A. Animal Choir
   B. "We Are One in the Spirit"
   C. "Spirit of the Living God"
   D. "Spirit"

Materials

V. Animal Studies
   A. Animal Clue Game See Sharing the Joy of Nature, 52-59.
   B. Items in Sharing Nature with Children
   C. Study the process of respiration and compare how different animals breathe. — See The Way Nature Works, 126-127.
   D. Sticky Web (3/37f)

VI. Bible Study - Acts 2:1-20
   A. Play some breathing games — Balloons, straws, etc.
   B. Discuss the importance of breathing for humans (air outside of us and within us)
      a. Talk about air that is something always around us.
      b. Do all things living need air?
   C. Tell the story of the first Pentecost (Acts 1:13) with emphasis on:
      a. Wind (vs. 2)
      b. Flame (vs. 3)
      c. Speaking in various languages (vs. 11)
      d. People talking about the many great things God does
   D. The leader might want to playfully ask the children:
      a. What languages do animals use?
      b. How do animals communicate? (noises, odors, actions, etc.)
   E. The point of this story is to be able to talk about
      1. God as Spirit
      2. God is all around us
      3. God is always acting
      4. Does God also act on animals?

VII. Building a Zoo
   Follow some instructions in the book. See Coordinator for supplies.

VIII. Native People Animal Stories
   Select some simple stories. Talk about how Native People tell a lot of stories about animals.

IX. Arts and Crafts
   A. Draw favorite animal
   B. Shape an animal from clay
   C. Make a portion of the zoo
   D. Mosaics

X. Worship Ideas
   See "Liturgy of Names" (I B 12)

XI. Things to Do at the Zoo
   A. How do animals breathe?
   B. Look for demonstration how energy flows

Materials

XII. Plans for the next day

Ask children to go home and learn about the animal they discussed earlier. They can report back on the next day. It is also possible for them to bring a picture.

DAY 2

Materials

MESSAGE: God speaks to us telling us how to live both in the Bible and in the natural world.

I. Get Reacquainted
   A. With people -
      1. Learn the any new names and remember the old ones.
      2. Ask children if they want to keep their favorite animal from the previous day or change it. They must then tell what they know about the new animal.
   B. With the animals
      1. The leader should record the animals from the previous day and be prepared to relate information about the animals selected at some point in the day.
      2. Talk about the what is known about the animals. Ask the children if they can learn anything from the animals.
   C. Go on a hike and ask the children to look for two things:
      1. Birds
      2. What animals do to protect themselves

II. Morning Prayer
   A. Go to your prayer place
   B. Prayer Content:
      1. Be silent.
      2. Ask children to listen to the many sounds and count them.
      3. Share.
         a. How many sounds do they hear?
         b. What sounds did they hear?
      4. Offer a prayer indicating that we listen to what God says to us.
      5. Develop a litany and ask the children to respond with these words: We listen for your voice, O God.

III. Games
   A. Do a form of "Simon Says"
   B. Select an Native People game
   C. Smaug's Jewels

IV. Songs
   Learn:
      You will never learn to care for the earth
      Until you learn to listen to the earth.
      Listen. Listen. Listen.

V. Animal Studies
   A. Yesterday talked about how all animals need air. What else do we need to survive?
   B. Echolocation (16/196ff)
   C. Predator/Prey games

Materials

1. Oh Deer (130/131)
2. Predator and Prey (2/170f)
3. Silent Stalking (15)

VI. Bible Study - Matthew 6 and I Samuel 3:1-4:1a
A. Tell each of the stories
B. Make the points that:
1. We learn from nature (Matthew 6)
2. God speaks to us (I Samuel)

VII. Building a Zoo
Continue the project. Make sure animals are alive.

VIII. Native People Animal Stories
A. Select some simple stories.
B. The Rabbit Dance

IX. Arts and Crafts
A. Cut out nature shapes
B. Salt Jars

X. Worship Ideas
Look at Jesus and the Animals (II B 4)

XI. Things to Do at the Zoo
Look at ways animals are able to survive: camouflage, especially other adaptations, e.g., speed, stealth, etc.

XII. Plans for the next day:
Bring things from home to contain animals.

DAY 3

Materials

MESSAGE: Worship is very important in our lives.

I. Opening Activity
   A. Visit a worship center and look at all the things used in worship.
   B. Ask the children to stand in a place that is meaningful to them and explain why that place is meaningful to them.
   C. Talk about fences
      1. Visit a fence.
      2. What are fences for?
      3. Visit the alter rail (hopefully one exists) and talk about how these were originally fences to keep animals out. The sanctuaries did not have doors and windows.

II. Morning Prayer
   A. Go to your prayer place
   B. Prayer Content:
      1. Offer prayers of thanksgiving. Children suggest a list.
      2. Learn song: "We Thank You God for Giving Us _____"

III. Games
   A. Circle Dancing
   B. Rattle Snake
   C. Triangle Tag
   D. Pass a Clap

IV. Songs
   Learn songs of thanksgiving

V. Animal Studies
   A. Use of scent for communication
   B. Learn about animals seen in urban and suburban setting. Notice rabbits - mice - squirrels - chipmunks
   C. Zoos and Endangered Species (Day IV)
   D. City Animal
   E. Urban Animal

VI. Bible Study - Luke 2:22-40 - Jesus at the Temple with His Parents

(In telling this story pause and ask the children if they can compare some of their experiences to what you are saying.)

Jesus' mother and father, Mary and Joseph, went to the temple on a regular basis. Some time there were specific things they would celebrate. (Ask the children about special celebrations in the church during worship, e.g., baptisms, holy communion, weddings, etc.)

Materials

Early in Jesus' life the family went to the temple for the rite of purification (details on this are in Leviticus 12:2-8). At this time the first person to be born in the family is presented to God and an animal sacrifice is offered. (Who are the first born children in the group?)

In the temple was a man named Simeon. He was a good man. People respected him. They believed he was filled with the Holy Spirit. (Can you think of any people you know that seem like they are "close to God?")

Simeon had been promised that he would see a very special person before he died. This person would be the person God would send to change things in the world.

When Mary and Joseph brought Jesus to the temple they brought him to Simeon. Somehow Simeon knew this person was that very special person he had been promised to see before he died. (We all know who this person is, don't we? Jesus.)

Simeon was so happy he sang a song. (Do you sing when you are happy or do you become happy when you sing?) Simeon was really excited, and he could not stop himself from singing.

The song Simeon sang as he was holding the child Jesus said this:

Now that I have seen what God promised I can die in peace.
I have seen the person who will change the world.
God has given all of us a person whom all people can see.
He has come for every person in the world.
He is like a light shining in darkness.

Mary and Joseph were a little surprised at Simeon's response. In a way they knew that Jesus was special, but now he appeared to be more special.

Then Simeon put his hand on Jesus and said some very important words. Simeon said that Jesus will make a difference, but he will be hurt as well. (What do you think Simeon was talking about? How do you think Jesus would be hurt? Yes, he would died on a cross.)

There was another person in the temple. Her name was Anna. She was a very old lady, 84 years old. That was very old in those days. In contrast to Mary she was really old, because Mary was in her teens. Anna spent all of her time in the temple praying and going without food (a way of worship).

Materials

When she saw Jesus she became excited. Sh thanked God and began to talk about how Jesus would change the world.

Mary, Joseph, and Jesus returned home. This had been a very exciting day.

As Jesus grew up he and his parents went to the temple on very special days. That is where they spent time worshipping God. At least once a year the family would go to the temple.

One time when Jesus was 12 years old they attended a ceremony in the temple. When the festivities were over the family along with a large crowd of people began to return home. The crowd was so big that Jesus' parents thought he was with everyone. Little did they know that Jesus was still back at the temple talking with the teachers.

However, at one point on the journey Mary and Joseph began to look for Jesus. He was no where to be found. For three days they searched for him. (How would you parents feel if they could not find you for several days?)

In their search for Jesus they eventually found him in the temple talking with the teachers. What do you think Mary and Joseph said to Jesus? Do you think they balled him out? They sure did! The were upset. They had been looking for him for three days, and they were frantic. Jesus responded to them with these words, "Why were you looking for me? Don't you know I must be in my Father's house?"

They left the temple and headed home. There he continued to grow up. He was a good children. Obedient.

Why do you think this story is in the Bible?

Jesus was a good Jewish boy. He lived in a good Jewish family. He found it important to join in the worship of God and particularly in the celebrations.

What do we do when we worship God?
We talk to God.
We talk with each other.
God talks with us.

VII. Building a Zoo
Continue the project

Materials

VIII. Native People Animal Stories
- A. Select some simple stories.
- B. The First Flute

IX. Arts and Crafts
- A. Make a simple weave
- B. Bolos
- C. Masks

X. Worship Ideas
- A. Baptism
- B. Celebrating Many things

XI. Things to Do at the Zoo
- Look at the ways animals cleanse themselves.

XII. Suggests for next day:
- Bring pets

DAY 4

Materials

MESSAGE: Christian people are to show love to everyone.

I. Opening Activity - Show and Tell
   A. Invite the children to share their pets.
   B. Ask the children to tell how they show their pets: love, joy, patience, kindness, generosity, and self-control
   C. Do they talk to their pets? Why?

II. Morning Prayer
   A. Go to your prayer place
   B. Prayer Content:
      1. Ask children to suggest some things that are easy to pray for.
      2. Next, ask them to list what they think are difficult (hard) people, situations, things, etc. for which to pray.
      3. Maybe they should think about both certain types of people and certain types of animals - ones easy to love and ones they do not like, that is ones hard to love.
      4. Leader offer a collected prayer.

III. Games
   A. Select some Native People games
   B. Towers

IV. Songs
   "Love, Love, Love, That's What It's All About"

V. Animal Studies
   A. Study insects
   B. Make an insect
   C. Insect scavenger hunt
   D. Inspect an insect
   E. Yuk a Bug!

VI. Bible Study - Good Samaritan - Luke 10:25-37. (Also using Galatians 5:22-23: love, joy, peace, patience, kindness, generosity, faithfulness, gentleness, and self-control.)

(Tell the story of the Good Samaritan and try to use the "fruits of the Spirit" from Galatians 5 as you relate the story. The following is an example of what can be done.)

This is a story Jesus told.

Once there was a man walking along a highway. He was attacked by some thieves. They stole his money, and they hurt him so badly that they thought he was dead.

He was lying along the side of the road. He could not do anything for himself.

Materials

Two Jewish religious men walked by him. When they saw him they crossed to the other side of the road. One was a priest and the other a Levite. These were people who were responsible in the temple.

(There may have been good reasons for these two men not willing to touch the fallen man. They may not have had the skills to help the man at all. Also, there was the idea that holy people touched only holy things. In the event of a person who was injured and dirty they would contaminate themselves. The reason for this information is so we do not make light of why these two men avoided the fallen man.)

However, along the road came another man, a Samaritan. He was different than the Jewish religious leaders. In fact, the Jewish people did not think very highly of Samaritans because they had broken away from the Jewish ways. (Can you think of any kind of people you do not like because they are different than you are?)

The Samaritan went to the man, and, showing kindness and gentleness, he cleaned his wounds and bandaged them. Then he put the man on his animal and took him to a hotel. There the Samaritan took care of him.

The next day the Samaritan man had to continue on his way. He went to the hotel owner and gave him money and asked him to look after the man while he was gone. He also said that he would return to the hotel. If caring for the man cost more than the money he left he would pay the rest. This man was extremely generous.

The Samaritan had special gifts. He was kind, gentle, and generous. (Can the children remember examples of this from the story and repeat the examples to the leader?)

The leader should note that there was one gift the Samaritan had above all. He chose to take a chance and show love to a man even though he may have been different that he is. He chose not to let differences get in the way of expressing his love.

(The leader can embellish the story as much as possible or keep it very simple depending upon the audience.)

VII. Building a Zoo
Continue the project

VIII. Native People Animal Stories
A. Select some simple stories.
B. Why the Possum Has a Naked Tail

Materials

C. Coyote and Rabbit
D. Coyote and the Fawn's Stars
E. Coyote and Spider Woman

IX. Arts and Crafts
Simple pottery

X. Worship Ideas
Celebrate the Gifts God Has Given to Each Person

XI. Things to Do at the Zoo
A. Select certain species and discover how they fit into the ecosystem.
B. What is their niche?

XII. Plans for the next day:
Ask children to ask their parents for names of people they know are sick. They can possibly learn what there sickness is.

DAY 5

Materials

MESSAGE: Followers of Jesus are expected by Jesus to continue his acts of healing.

I. Opening Activity
   A. Visit a sick or home bound person.
   B. Take a walk as a group and persons in the group be given certain inflictions for which the rest of the group must care: blindness, deafness, broken arm, broken leg, etc.

II. Morning Prayer
   A. Go to your prayer place
   B. Prayer Content:
      Pray for people we know who need healing.

III. Games
   Select some Native People games

IV. Songs

V. Animal Studies
   Spiders and Spider Webs
   1. What disturbs the web?
   2. How is web repaired?

VI. Bible Study - Luke 5:12-2, 6:6-11, 7:1-17 and 9:1-6

(These are several healing stories in Mark that the story teller can develop. The story line concludes with the teaching from Luke that the disciples of Jesus are to continue Jesus' healing ways.)

Healing Stories:
   1. The man covered with leprosy - 5:12-16
   2. The paralytic who was lowered through the roof - 5:17-26
   3. The man with the withered hand - 6:6-11
   4. The healing of the centurion's slave - 7:1-10
   5. The returning of life to the woman's only son - 7:11-17

Jesus instructs his disciples to continue teaching and healing - 9:1-6

VII. Building a Zoo
   Release any animals

VIII. Native People Animal Stories
   A. Select some simple stories.
   B. Coyote Takes Water from the Frog People
   C. Origin of Medicine

IX. Arts and Crafts
   Krist-Kins

Materials

X. Worship Ideas
   A. Commissioning of children to act as healers in the world.
   B. Promise to acts of forgiveness

XI. Things to Do at the Zoo
   Talk about how zoos help to preserve animals that would become extinct and the intention to help a population of endangered animals to survive.

Jan 26, 1993
Cha-Day

ST. PETER'S LUTHERAN CHURCH
Arenzville, Illinois

Audience: 5 2-4 year olds, 7 5-6 year olds, 1 first grader, 5 3-4th graders, and 2 6th graders. Children are highly verbal. Many are related. 4 adults will be available to help. One person is in charge of music and another in charge of the T-shirt iron on.

MESSAGE: Like air that is all around us and fills us so we can breathe and have life, God (the Spirit) is all around us and in us to make us live and to connect us to everything.

	Materials
8:45 Participants Arrive	
9:00 I. Get Acquainted	
A. Learn the names: a process so each person knows the name of everyone else.	
B. Ask children to name their favorite animal and tell what they know about their favorite animal.	
II. Something Silly	
A. Each child act out their animal and the group mimics.	
B. Last time everyone acts out their own animal.	
III. Play the barn yard game in three or four groups using animals children have chosen. Might prayer	Peanuts & bags
IV. Go on a hike looking for critters	
A. Go to a common meeting place outside and ask the children to listen for many sounds, count them, and report.	
B. Divide into three groups with adults	
C. Give each of the groups several baby food jars and ask them to go on a hunt for insects and small critters they can put in the jars.	Baby food jars
D. Return to the common place and share critters.	Identification Books
1. If children do not know the names of the critters they are to make up their own.	
2. Identify critters, if necessary.	
V. Morning Prayer	
A. Find a place for prayer.	
1. Be intentional about the location. Maybe the children can select it.	
2. Everyone join hands in a circle in sing: "Ring around a rosey . . . They all fall down."	Song
B. Set up the jars with the critters so they are a part of the experience	
Tell the children they are going to join us for prayer.	
C. Prayer Content:	
1. Think of all the critters talked about and how they are all around us.	

Materials

2. Thank God that God is also around us, everywhere we look. God is there even when God is not seen. Then we call God "Spirit."

D. Introduce Psalm 104 — Song Sheet

(Snack Break)

VI. Learn about respiration

A. Play games myst.

1. Ping pong ball on the table and children blowing it around — Ping pong balls, Straws
2. A balloon relay race - played only by blowing the balloon. — Balloons

B. Remember your animal? How does it breathe?

C. Not all animals breathe through their mouths. Some breathe through their skin and others have gills. (See "Dwellers in the Deep," 124f, "Taking the Air," 125f, and "In and Out of the Water," 128f in The Way Nature Works.)

VII. Bible Study - Acts 2:1-20 — Bibles

A. Discuss the importance of breathing for humans (air outside of us and within us)

1. Talk about air that is something always around us.
2. Do all things living need air?

B. Tell the story of the first Pentecost (Acts 1:13) with emphasis on:

1. Wind (vs. 2)
2. Flame (vs. 3)
3. Speaking in various languages (vs. 11)
4. People talking about the many great things God does

C. The leader might want to playfully ask the children:

1. What languages do animals use?
2. How do animals communicate? (noises, odors, actions, etc.)
3. Do animals talk about what God does?

If animals could talk so we could understand what do you think they would tell us about

D. The point of this story is to be able to talk about

1. God as Spirit
2. God is all around us
3. God is always acting
4. Does God also act on animals?

11:15 Choir rehearsal

12:00 Lunch

12:30 Arts and Crafts Sculptures & models of animal, selected in morning

Materials

1:00 Younger children - rest time

VIII. Things to look for on a Spider Web Hunt (older children) (See "Architects in Silk," 252f, in How Nature Works.)
- A. Note the structure of the web. Draw it on pencil and paper. — Paper and pencil
- B. Are there bugs in the web (prey)?
- C. Skeletons nearby that show what the spider ate?

IX. Everyone (after brief rest by younger children) share Spider Web Hunt discoveries

X. Games:
- A. Parachute — Parachute any
- B. Web of Yarn - — Ball of Yarn (very long piece)
  1. How We are Connected
  2. Each person be an individual entity.
  3. Someone must be God

XI. Story Telling - "How the Spider Symbol Came to the People" from Keepers of the Animals, 31.

XII. Closing Songs and Worship
- A. "Spirit of the Living God"
- B. "Spirit"
- C. "We Thank You God for Giving Us ..."
- D. "Sing Alleluia to the Lord"
  - God is alive in you and me
  - God's Spirit moves throughout the World
- E. "Psalm 104" — Song Sheet
- F. "Father, I Adore You"
- G. "I Like the Mountains . . ."
- H. "Boom Chick a Boom"

Closing Comments + Prayer

Dismissal

file: 93RES$DAYCAMP$ARNZVIL
revised: 6/25/93

PSALM 104

REFRAIN

A A D E A D

I WILL SING ALL MY LIFE TO THE LORD; TO MY (GOD) I'LL SING AS LOUG AS I

E A D A

LIVE; WHEN MY SONG (GOD'S) PRESENCE ENTERS, I'LL RE—JOICE IN THE LORD BLESS THE

E A D A

LORD, O MY SOUL PRAISE THE LORD.

E A

VERSE 1 O LORD, OUR GOD HOW GREAT YOU ARE IN—DEED YOU'RE

2 THE EARTH, YOU'S TAB LISHED FIRMLY ON IT'S BASE, YOU

9. YOU MADE THE MOON TO MARK THE YEAR IN MONTHS, THE

12. ALL GLO— RY BE TO GOD FOR—EV ER. MAY

E A

1 CLOTHED WITH MAJES—TY AND POWER YOU

SHAPE THE WORLD CAUSE CHA—OS CEASE YOU

1 SUN TO SET THE TIME OF DAY. THE

JOY BE FOUND IN ALL GOD'S WORKS. THE

F# B m

1 HIDE YOURSELF BEAIND YOUR ROBE OF LIGHT CALL

2 CALL IT GOOD, AND GRANT ALL THINGS THEIR WORTH YOU

9 NIGHT SO ANIMALS CAN STALK THEIR PREY AND

12 EARTH DOES TREMBLE WHEN GOD LOOKS AT IT BY GOD'S

B E D.C. REFRAIN

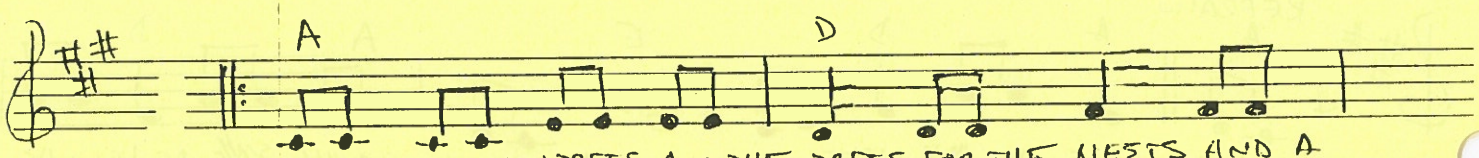
1 ALL YOU MAKE YOUR MESSEN—GERS.

2 SET IT'S BOUNDS GIVE THINGS THEIR PLACE SO I WILL

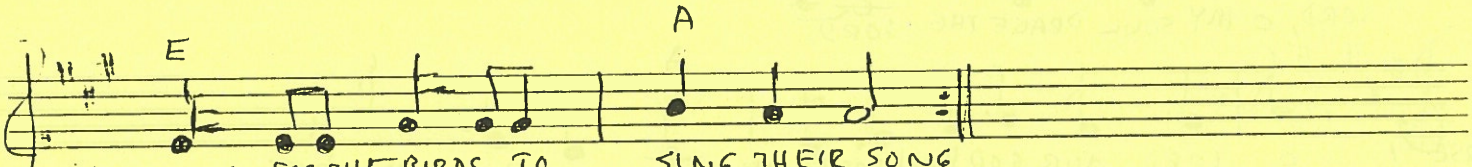
SO I WILL

9 LIGHT SO WE CAN TOIL AND PRAY SO I WILL

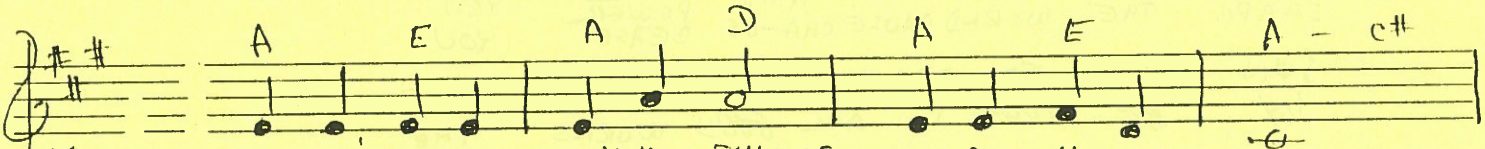
12 TOUCH THE MOUNTAINS POUR OUT SMOKE, SO I WILL



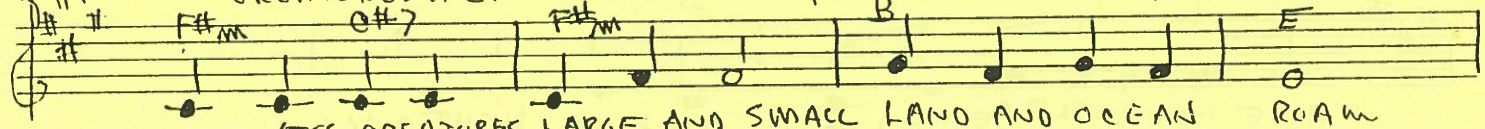
3. WATER FOR THE TREES AND THE TREES FOR THE NESTS AND A
4. WATER IN THE VALLEY BE— TWEEN THE HILLS FOR THE
5. WATER FROM HEAVEN TO— MAKE PLANTS GROW FOR THE
6. WATER FOR THE VINE AND THE VINE FOR THE GRAPE AND THE
7. WATER FROM THE EARTH FOR THE O—LIVE TREE FOR THE
8. WATER FOR THE WHEAT THAT GIVES US FLOUR FOR THE



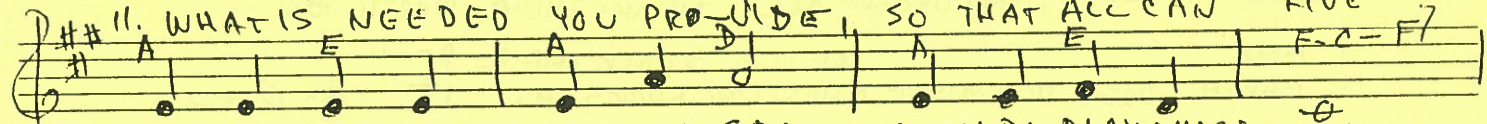
3 PLACE FOR THE BIRDS TO SING THEIR SONG
4. BEASTS OF THE WILD TO QUENCH THEIR THIRST
5. CATTLE IN THE FIELD AND FOR US TO TOIL
6. GRAPE FOR THE WINE TO MAKE US GLAD
7. OIL THAT MAKES OUR FACES— SHINE
8. BREAD WE BAKE TO GIVE US STRENGTH D.C.



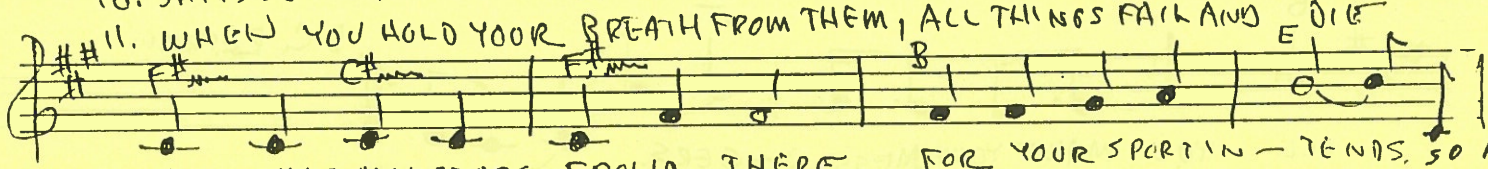
10. LORD YOU'VE MADE SO MANY THINGS WIS DOM YOU HAVE SHOWN
11. CREATURES ALL RE— LY ON YOU, SUSTENANCE TO GIVE



10. COUNT-LESS CREATURES LARGE AND SMALL LAND AND OCEAN ROAM
11. WHAT IS NEEDED YOU PRO—VIDE, SO THAT ALL CAN LIVE



10. SHIPS SET SAIL UP— ON THE SEA FISH DO PLAY THERE— IN
11. WHEN YOU HOLD YOUR BREATH FROM THEM, ALL THINGS FAIL AND DIE



10. AND THE MONSTERS FROLIC THERE FOR YOUR SPORT IN— TENDS, SO RE
11. WHEN YOU BREATHE LIFE YOU RESTORE GIVE THE EARTH NEW— LIFE. SO RE

Suddenly, the chief ran right into a huge spider's web that had been strung between the trees across the trail.

How the Spider Symbol Came to the People

(Osage—Plains)

From the earliest days when they came together on this earth, the Osage people have been divided into two groups. These groups were the Sky People and the Earth People. The nine clans of the Sky People always lived in the northern half of the village. The fifteen clans of the Earth People lived in the southern half of the village. These clans looked to the animals to be their teachers, to serve as symbols for them to live strong lives. Each clan had more than one animal as its symbol. One of these clans was called the Isolated Earth People. This is the story of how the spider became one of the symbols of that clan.

One day, the chief of the Isolated Earth People was hunting in the forest. He was not just hunting for game, he was also hunting for a symbol to give life to his people, some great and powerful animal that would show itself to him and teach him an important lesson. As he hunted, he came upon the tracks of a huge deer. The chief became very excited.

"Grandfather Deer," he said, "surely you are going to show yourself to me. You are going to teach me a lesson and become one of the symbols of my people."

Then the chief began to follow the deer's tracks. His eyes were on nothing else as he followed those tracks and he went faster and faster through the forest. Suddenly, the chief ran right into a huge spider's web that had been strung between the trees across the trail. It was so large and strong that it covered his eyes and made him stumble. When he got back up to his feet, he was very angry. He struck at the spider, which was sitting at the edge of the web, but the spider dodged aside and climbed out of reach. Then the spider spoke to the man.

"Grandson," the spider said, "why do you run through the woods looking at nothing but the ground? Why do you act as if you are blind?"

The chief felt foolish, but he felt he had to answer the spider. "I was following the tracks of the great deer," the chief said. "I am seeking a symbol to give life and strength to my people."

"I can be such a symbol," said the spider.

"How could you give strength to my people?" said the chief. "You are small and weak and I didn't even see you as I followed the great deer."

"Grandson," said the spider, "look upon me. I am patient. I watch and I wait. Then all things come to me. If your people learn this, they will be strong indeed."

The chief saw that it was so. Thus the spider became one of the symbols of the Osage people.

DISCUSSION

Grandmother Spider accomplishes many important things in these two stories. She helps Tawa, the Sky God, create Earth and all things upon it. It is then left to Grandmother Spider to bring order into the formlessness of Creation. She creates and names the Indian nations, brings the people out of the dark underworld and into the light of day, and, finally, separates the people into clans. Each clan is headed by an animal that leads those people to their homeland. Native Americans still follow these clan animals and live in many of these same places.

In "How Grandmother Spider Named the Clans," we

Dwellers in the Deep

How fish evolved and survive

There are over 21,000 different kinds of fish, ranging from tiny tropical species to sharks 40 feet (12 meters) long weighing over 12 tons. Many live near the ocean surface, but some survive in the abyss; lantern fish migrate up and down hundreds of yards between the surface and the depths every day. The icefish lives under the polar ice, whereas desert pupfish live in hot springs. Both lungfish and walking catfish can survive long periods on land and are capable of breathing air. Salmon and eels travel thousands of miles to spawn.

The evolution of fish is not straightforward. Although in general there is a real progression from the jawless fishes of the oceans some 460-480 million years ago, through the first jawed fish of 450 million years ago and the sharklike fish of 380 million years ago, to the true bony fishes (*teleosts*) that first appeared 175 million years ago, the evolutionary success of the earlier types meant that they did not succumb to the competition and simply die out when newer, improved models came on the scene. Instead, they too went on evolving. The class of fish that contains the most species today – the "ray-finned" fish that have a single dorsal fin, pectoral fins lined with thin radial bones, scales that grow throughout life, a bony skeleton, and a swim bladder for flotation – derives from ancestors that appeared some 390 million years ago: they are a "modern" type of fish. The sharks (which are often described as relatively primitive) evolved later, between 190 and 135 million years ago.

Incomparable adaptability

Although most fish have the same basic body plan, they vary enormously in size and shape. Eels and pipefish are able to glide in and out of crevices in reefs, whereas copperband butterfly fish use a long, narrow snout for probing. Sea horses cling to weeds with their curling tails. Skates, rays, plaice and flounders have evolved flattened shapes for lying in ambush on the seabed. Some cave-dwelling fish may save energy by having no functional eyes or pigments.

Diets vary considerably, from tiny suspended particles of plant and animal material to algae (seaweeds) growing on the rocks, from corals and other invertebrates to other fish and even marine mammals. Some fish are parasitic on or inside other fish.

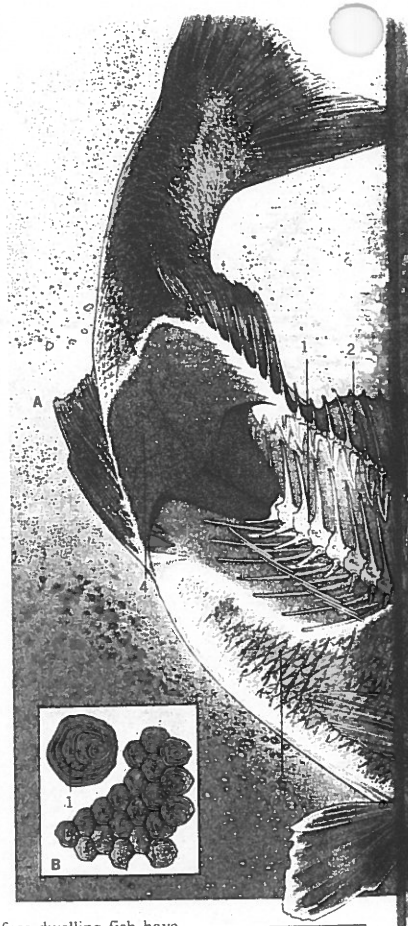
Sight across the spectrum

For the purposes of finding their food, most fish have color vision and laterally placed eyes that give them a wide field of view. In the deep-water gloom fish often have upward-directed eyes: they detect their prey by spotting its silhouette against the light coming down from above. They also have very large eyes to maximize light-gathering. Fish that live in caves where total darkness reigns have eyes that have degenerated into uselessness. A few surface-dwelling fish have eyes adapted for seeing in both water and air.

Sharks and rays, on the other hand, depend heavily on smell for detecting prey. Eels have the most acute sense of smell, through their very long nasal sacs. They are believed to find their way across the oceans by detecting minute changes in the chemical composition of different stretches of water.

The electrical web

As well as fish that use electrical fields to detect their prey, or navigate, electricity is employed as a means of defense or attack for some species. Using organic batteries that probably evolved from muscles or nerves, skates, rays, and electric eels are among the fish that possess the faculty; the latter generating up to 600-volt pulses from batteries that occupy nearly half its body length, which can be as much as 8 feet (2.5 meters).

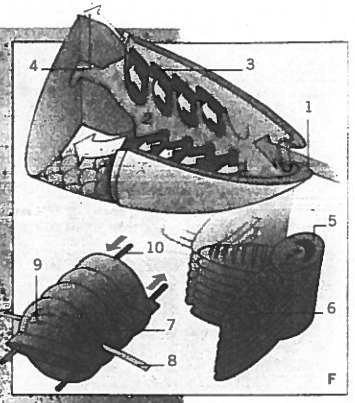


Sea bass **[A]**, *like most modern fish, belong to the class* Osteichthyes, *or bony fish. They have a bony skeleton* [1] *with fins* [2] *supported by bony rays* [3]. *Fins and powerful muscles* [4] *(overlapping in blocks corresponding to a pair of vertebrae) in the flexible body provide propulsion for swimming. The streamlined body, which tapers smoothly at each end, offers minimal water resistance; most fish have scales* [5] *– bony skin outgrowths. Gills* [6], *eyes* [7] *and nostrils* [8] *enable the fish to breathe, see and smell underwater.*

Modern fish *have thin, overlapping* cycloid **[B]** *or* ctenoid *scales. Fish scales are arranged in rows, each one having a series of tiny ring-shaped ridges* [1] *– growth rings that can show the age of a fish. Scales are both a protection and a flexible covering. Because they are translucent, the scales let the pigmentation on the skin of the fish show through from below.*

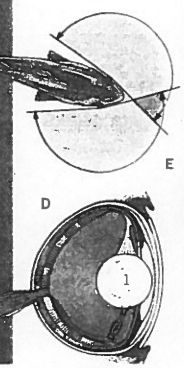
Placoid scales **[C]** *are found on primitive fish with a cartilaginous exoskeleton, such as sharks.* Ganoid *scales are another type of scale found on primitive fish, such as the bony gar. These diamond-shaped scales contain ganoin, which gives a silvery, mirrorlike look.*

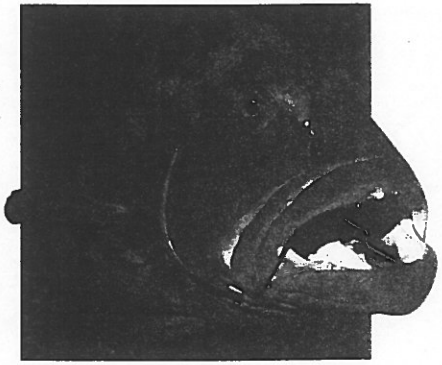
Connections: Animal Adaptation to Pressure 146 Breathing 126 Fish Reproduction 162 Lake Life 326 Ocean Life 332 River Life 328 Vision 278



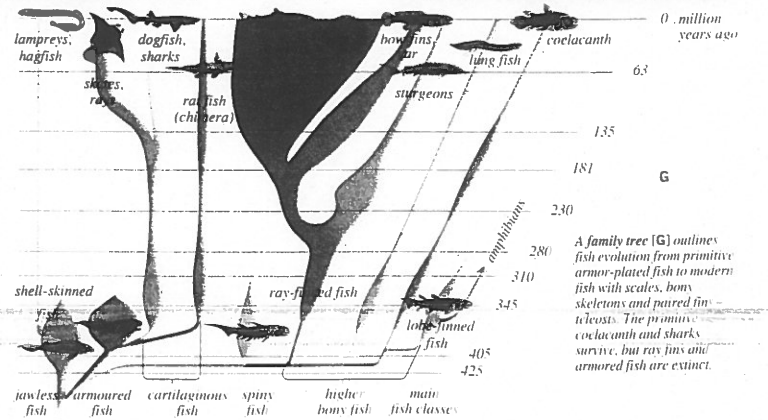
Fish breathe oxygen *dissolved in water and extracted by gills* **[F]**, *which can achieve 80 percent extraction rates, over three times the rate of human lungs from air. Water enters the mouth* [1], *passes through the gill chamber* [2] *over the gills* [3] *and exits via a gill flap* (operculum) [4]. *Flow is maintained by the pumping of the mouth, synchronized to the opening and closing of the operculum. The gills are rows of bony rods* [5], *to which are attached fleshy filaments* [6] *rich in blood capillaries to absorb oxygen. Each filament has fine secondary flaps* (lamellae) [7] *to maximize the gas exchange surface area, which, in active fish like mackerel, can be over ten times the outer body area. Water* [8] *passes over the gills against the capillary blood flow* [9]: *this "counter-current flow" ensures water always passes over deoxygenated blood, maximizing oxygen absorption. Blood vessels* [10] *circulate the blood.*

Cleaner fish *(below) are common on coral reefs and lead a symbiotic life, eating the external parasites on other fish, including large predators, which open their mouths and gill covers to be cleaned inside. Fish recognize a cleaner fish by its very distinctive coloration and its "invitation" dance.*





Fish eyes **[D]** *are adapted to see underwater. Unlike a human lens, a fish lens* [1] *is a perfect sphere, which may reduce image distortion. The eyes protrude somewhat to give reasonable allround vision, but there is very little overlap between each eye's field of vision* **[E]**, *hence 3-D vision is poor. Fish have no eyelids – there is no need to prevent the eye drying up – and they also lack pupils that can vary their size. Most fish have some color vision, but sharks and rays appear to see only in black and white. Unlike cave-dwellers, abyssal fish have functioning eyes, probably used to detect luminous deep-sea creatures.*



A family tree **[G]** *outlines fish evolution from primitive armor-plated fish to modern fish with scales, bony skeletons and paired fins – teleosts. The primitive coelacanth and sharks survive, but ray fins and armored fish are extinct.*

Dwellers in the Deep

How fish evolved and survive

There are over 21,000 different kinds of fish, ranging from tiny tropical species to sharks 40 feet (12 meters) long weighing over 12 tons. Many live near the ocean surface, but some survive in the abyss; lantern fish migrate up and down hundreds of yards between the surface and the depths every day. The icefish lives under the polar ice, whereas desert pupfish live in hot springs. Both lungfish and walking catfish can survive long periods on land and are capable of breathing air. Salmon and eels travel thousands of miles to spawn.

The evolution of fish is not straightforward. Although in general there is a real progression from the jawless fishes of the oceans some 460-480 million years ago, through the first jawed fish of 450 million years ago and the sharklike fish of 380 million years ago, to the true bony fishes (*teleosts*) that first appeared 175 million years ago, the evolutionary success of the earlier types meant that they did not succumb to the competition and simply die out when newer, improved models came on the scene. Instead, they too went on evolving. The class of fish that contains the most species today – the "ray-finned" fish that have a single dorsal fin, pectoral fins lined with thin radial bones, scales that grow throughout life, a bony skeleton, and a swim bladder for flotation – derives from ancestors that appeared some 390 million years ago; they are a "modern" type of fish. The sharks (which are often described as relatively primitive) evolved later, between 190 and 135 million years ago.

Incomparable adaptability

Although most fish have the same basic body plan, they vary enormously in size and shape. Eels and pipefish are able to glide in and out of crevices in reefs, whereas copperband butterfly fish use a long, narrow snout for probing. Sea horses cling to weeds with their curling tails. Skates, rays, plaice and flounders have evolved flattened shapes for lying in ambush on the seabed. Some cave-dwelling fish may save energy by having no functional eyes or pigments.

Diets vary considerably, from tiny suspended particles of plant and animal material to algae (seaweeds) growing on the rocks, from corals and other invertebrates to other fish and even marine mammals. Some fish are parasitic on or inside other fish.

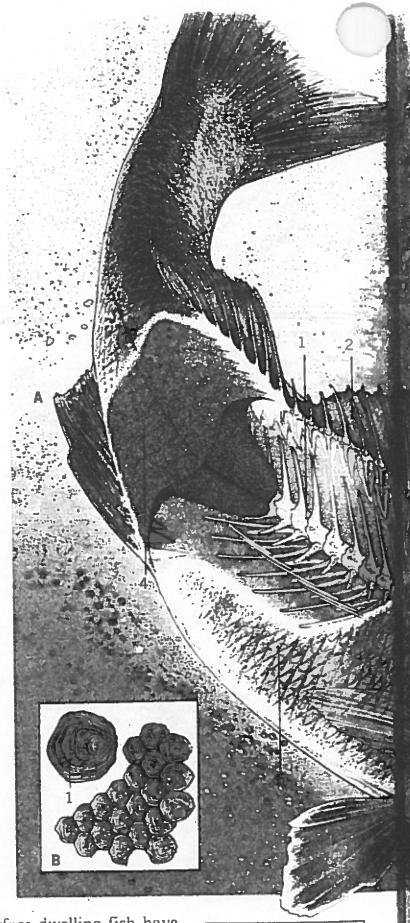
Sight across the spectrum

For the purposes of finding their food, most fish have color vision and laterally placed eyes that give them a wide field of view. In the deep-water gloom fish often have upward-directed eyes; they detect their prey by spotting its silhouette against the light coming down from above. They also have very large eyes to maximize light-gathering. Fish that live in caves where total darkness reigns have eyes that have degenerated into uselessness. A few surface-dwelling fish have eyes adapted for seeing in both water and air.

Sharks and rays, on the other hand, depend heavily on smell for detecting prey. Eels have the most acute sense of smell, through their very long nasal sacs. They are believed to find their way across the oceans by detecting minute changes in the chemical composition of different stretches of water.

The electrical web

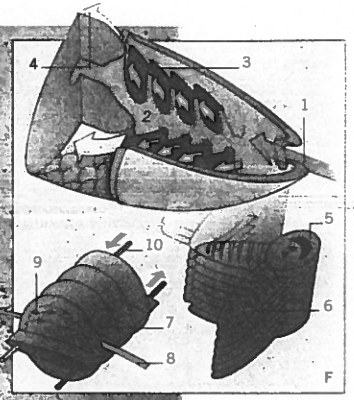
As well as fish that use electrical fields to detect their prey, or navigate, electricity is employed as a means of defense or attack for some species. Using organic batteries that probably evolved from muscles or nerves, skates, rays and electric eels are among the fish that possess the faculty; the latter generating up to 600-volt pulses from batteries that occupy nearly half its body length, which can be as much as 8 feet (2.5 meters).



Sea bass (A), *like most modern fish, belong to the class* Osteichthyes, *or bony fish. They have a bony skeleton* (1) *with fins* (2) *supported by bony rays* (3). *Fins and powerful muscles* (4) *(overlapping in blocks corresponding to a pair of vertebrae) in the flexible body provide propulsion to swimming. The streamlined body, which tapers smoothly at each end, offers minimal water resistance; most fish have scales* (5) *– bony skin outgrowths. Gills* (6), *eyes* (7) *and nostrils* (8) *enable the fish to breathe, see and smell underwater.*

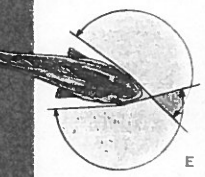
Modern fish have thin, overlapping cycloid (B) *or* ctenoid *scales. Fish scales are arranged in rows, each one having a series of tiny ring-shaped ridges* (1) *– growth rings that can show the age of a fish. Scales are both a protection and a flexible covering. Because they are translucent, the scales let the pigmentation on the skin of the fish show through from below.*

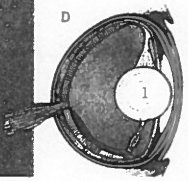
Placoid scales (C) *are found on primitive fish with a cartilaginous exoskeleton, such as sharks.* Ganoid *scales are another type of scale found on primitive fish, such as the bony gar. These diamond-shaped scales contain ganoin, which gives a silvery, mirrorlike look.*

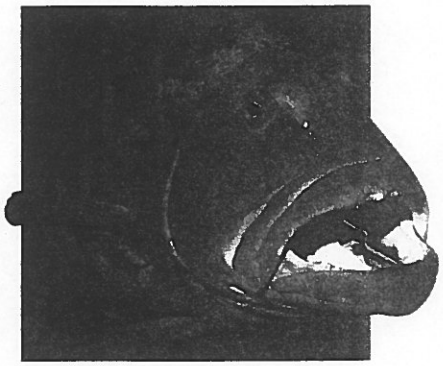


***Fish breathe oxygen** dissolved in water and extracted by gills* (F), *which can achieve 80 percent extraction rates, over three times the rate of human lungs from air. Water enters the mouth* (1), *passes through the gill chamber* (2) *over the gills* (3) *and exits via a gill flap* (operculum) (4). *Flow is maintained by the pumping of the mouth, synchronized to the opening and closing of the operculum. The gills are rows of bony rods* (5), *to which are attached fleshy filaments* (6) *rich in blood capillaries to absorb oxygen. Each filament has fine secondary flaps* (lamellae) (7) *to maximize the gas exchange surface area, which, in active fish like mackerel, can be over ten times the outer body area. Water* (8) *passes over the gills against the capillary blood flow* (9); *this "counter-current flow" ensures water always passes over deoxygenated blood, maximizing oxygen absorption. Blood vessels* (10) *circulate the blood.*

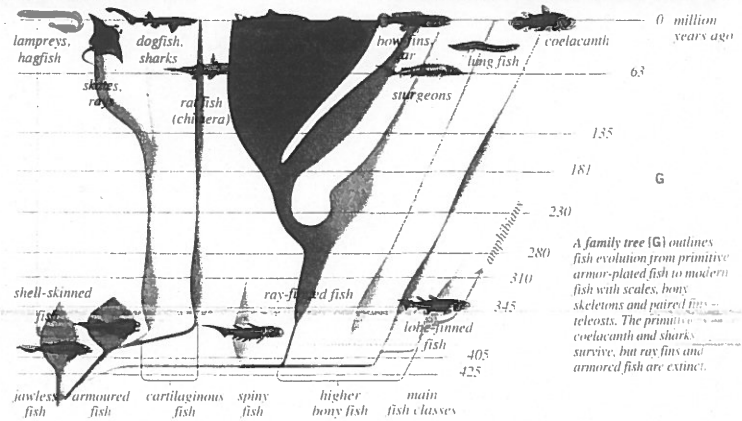
***Cleaner fish** (below) are common on coral reefs and lead a symbiotic life, eating the external parasites on other fish, including large predators, which open their mouths and gill covers to be cleaned inside. Fish recognize a cleaner fish by its very distinctive coloration and its "invitation" dance.*







***Fish eyes** (D) are adapted to see underwater. Unlike a human lens, a fish lens* (1) *is a perfect sphere, which may reduce image distortion. The eyes protrude somewhat to give reasonable allround vision, but there is very little overlap between each eye's field of vision* (E), *hence 3-D vision is poor. Fish have no eyelids – there is no need to prevent the eye drying up – and they also lack pupils that can vary their size. Most fish have some color vision, but sharks and rays appear to see only in black and white. Unlike cave-dwellers, abyssal fish have functioning eyes, probably used to detect luminous deep-sea creatures.*

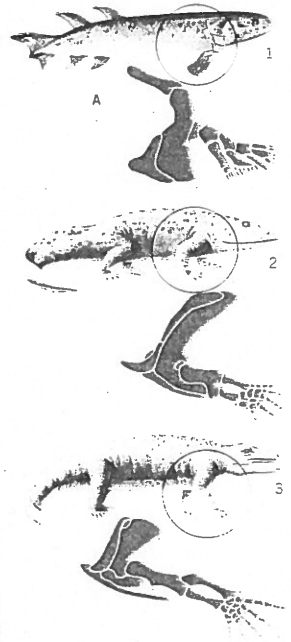


***A family tree** (G) outlines fish evolution from primitive armor-plated fish to modern fish with scales, bony skeletons and paired fins – teleosts. The primitive coelacanth and sharks survive, but ray fins and armored fish are extinct.*

In and Out of the Water

How amphibians live

Although amphibians are most familiar to us as frogs and newts, they can grow as large as the 4.5-foot (1.5-meter) Japanese giant salamander, weighing 220 pounds (100 kilograms). Some 370 million years ago the first creatures to leave the seas and walk on land were the amphibians. They pioneered the use of lungs for full-time air breathing, and were the first vertebrates to have true legs, tongues, ears and voice boxes. The increase in body area covered by the nerve cells led to those cells invading the brain: a step to intelligence. Today there are some 4,000 species of amphibian.



***The evolution** of the* pentadactyl *(five-fingered) limb* [A] *can be partly traced through the fossil record. The basic design was already present in lobe-finned fish such as* Eusthenopteron [1]. *Adapting to the terrestrial environment, the limb rotated downward and away from the body. In the first known amphibian,* Ichthyostega [2], *the limb is still compact and the body close to the ground.* Seymouria [3] *developed more extended limbs, which provided greater articulation and ground clearance.*

Despite being cold-blooded, and therefore particularly at the mercy of their environment, amphibians are found on all the continents except Antarctica, from the tropics to north of the Arctic Circle. There are three main groups: the *Urodela* (newts, mudpuppies, sirens and salamanders), the *Anura* (frogs and toads) and the *Gymnophiona* (caecilians or worm lizards). Many features distinguish the amphibians from other vertebrates. They have a three-chambered heart, paired lungs, which are reduced or absent in some salamanders and caecilians, a flattened skull, and teeth that can bend inward.

The breathing body

Unlike reptiles, amphibians have not developed waterproof skins. In fact, many species supplement lung breathing with gas exchange through their skins, which must be kept moist for this purpose. The lining of the mouth is also moist and well supplied with capillaries and can function in gas exchange. A few aquatic salamanders retain their larval external gills in the adult, and a few terrestrial forms have no lungs at all.

The senses also had to adapt to life on land. Eyelids and eye-moistening glands evolved, and true ears (with outer eardrums and two middle-ear bones, neither of which are found in fish ears) for detecting sound vibrations in air. At the same time, the voicebox and vocal sacs evolved – amphibians were the first vertebrates to have a larynx. For the sense of smell, internal nostril openings (*nares*) allow air to be taken into the lungs while the mouth is closed or when only the external nares are above water. This can also help when the amphibian is avoiding land predators.

An aquatic inheritance

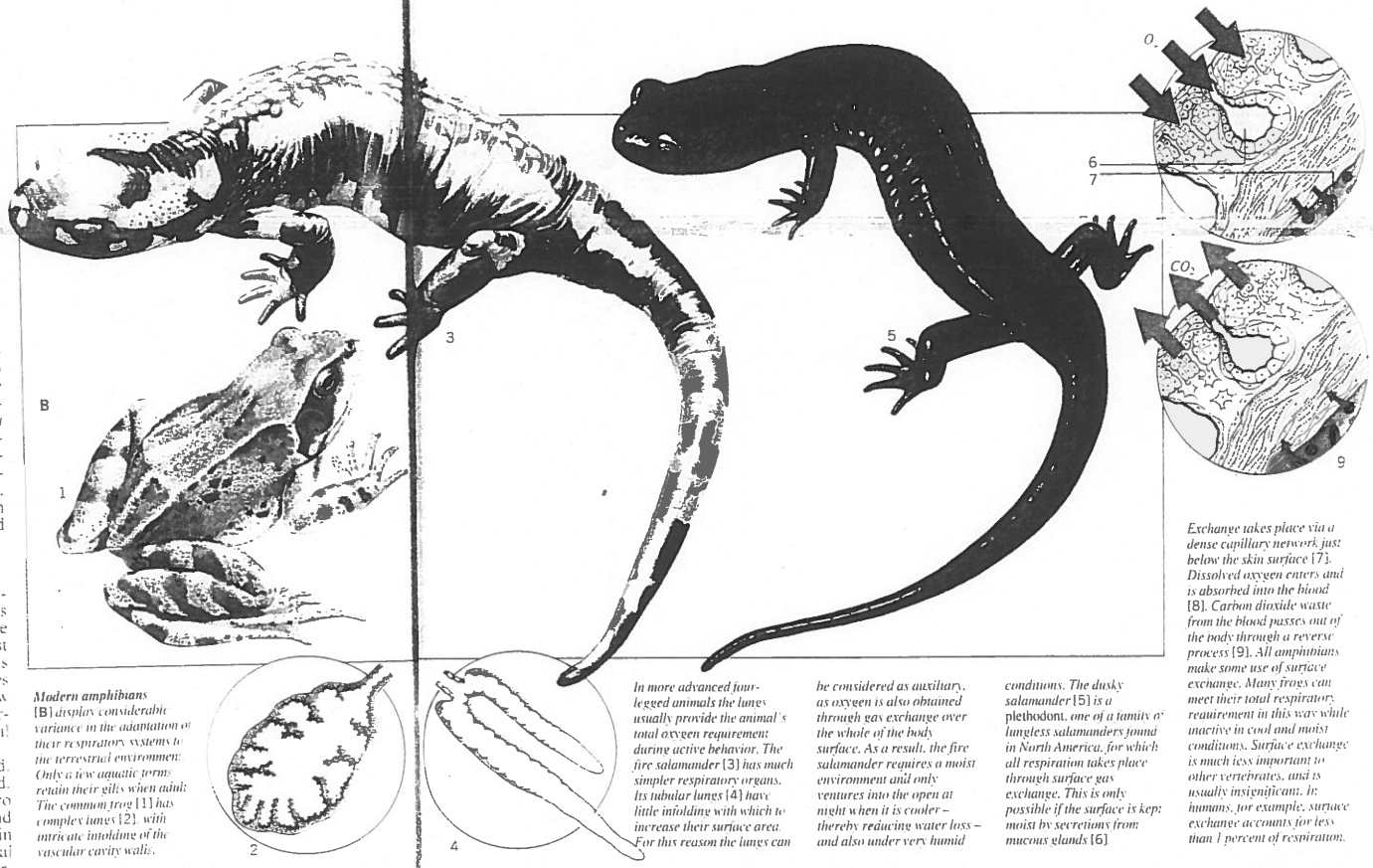
Amphibians have retained many of their adaptations to the aquatic life. When moving, many amphibians retain an undulating, fish-like motion, except for the frogs and toads, which evolved long hind limbs for hopping on land, or kicking out to swim. Also, many frogs and toads still discharge unfertilized eggs into the water, where sperm is then shed on to them for fertilization to occur.

Amphibians have kept their streamlined shape, and many species their webbed feet, for locomotion in water. Their inability to generate internal body heat confines them to the warmer parts of continents, but many species survive considerable cold by reducing their metabolic rates.

Surviving the desert

Amphibians are relatively common in deserts and other arid regions. They avoid overheating by burrowing in the day and emerging at night. Their main problem is the unpredictable water supply. Certain species can store up to half their body weight of water in the bladder. Some frogs and toads are remarkably tolerant of water loss – the Western spadefoot toad can withstand up to 60 percent reduction in its body water. Another adaptation is to retain urea in the blood, thus permitting the uptake of water by osmosis from even apparently dry soils. Most terrestrial frogs also have a patch of skin rich in blood capillaries in the pelvic region, which takes up water when sitting on damp earth.

Connections: Animals in Heat and Drought 142 Breathing 126 Early Evolution 92 Reptiles 130 Swimming 210



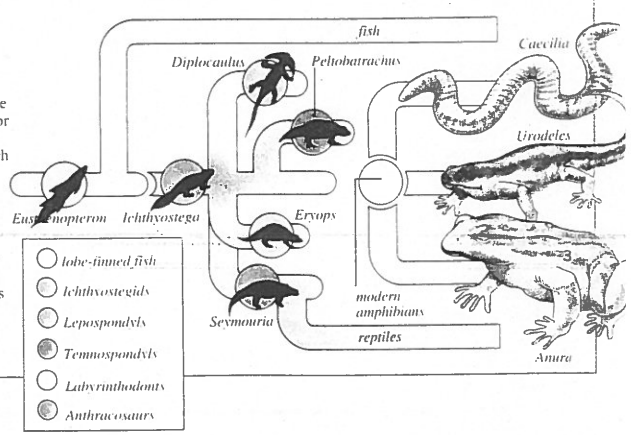
Modern amphibians [B] *display considerable variance in the adaptation of their respiratory systems to the terrestrial environment. Only a few aquatic forms retain their gills when adult. The common frog* [1] *has a complex lungs* [2], *with intricate infolding of the vascular cavity walls.*

In more advanced four-legged animals the lungs usually provide the animal's total oxygen requirement during active behavior. The fire salamander [3] *has much simpler respiratory organs. Its tubular lungs* [4] *have little infolding with which to increase their surface area. For this reason the lungs can be considered as auxiliary, as oxygen is also obtained through gas exchange over the whole of the body surface. As a result, the fire salamander requires a moist environment and only ventures into the open at night when it is cooler – thereby reducing water loss – and also under very humid conditions. The dusky salamander* [5] *is a* plethodont, *one of a family of lungless salamanders found in North America, for which all respiration takes place through surface gas exchange. This is only possible if the surface is kept moist by secretions from mucous glands* [6].

Exchange takes place via a dense capillary network just below the skin surface [7]. *Dissolved oxygen enters and is absorbed into the blood* [8]. *Carbon dioxide waste from the blood passes out of the body through a reverse process* [9]. *All amphibians make some use of surface exchange. Many frogs can meet their total respiratory requirement in this way while inactive in cool and moist conditions. Surface exchange is much less important to other vertebrates, and is usually insignificant in humans, for example, surface exchange accounts for less than 1 percent of respiration.*

Missing Links

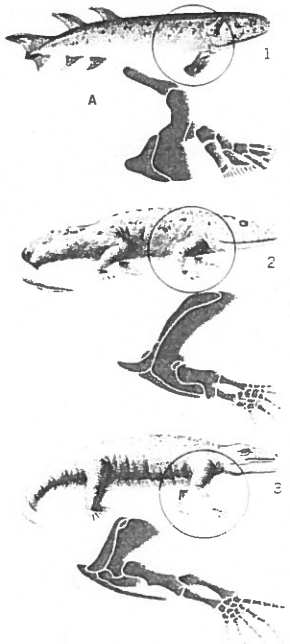
The first amphibians evolved from lobe-finned fish about 370 million years ago. These fish, like coelacanths, had bony supports in their fins, which might have let them crawl out of the water, and lungs and internal nasal openings for breathing air. The fossil record of amphibians is poor. The earliest amphibians on record, such as *Ichthyostega*, had already evolved hip and shoulder girdles to support the new limbs and ribs to protect the internal organs. One of the largest of them was *Mastodonosaurus*, up to 4 m (13 ft) long. Until the evolution of the dinosaurs, amphibians dominated the land. By about 135 million years ago most were extinct. There are no fossils to link modern amphibians with these ancient forms and no record of the divergence into caecilians [1], newts and salamanders [2], and frogs and toads [3].



In and Out of the Water

How amphibians live

Although amphibians are most familiar to us as frogs and newts, they can grow as large as the 4.5-foot (1.5-meter) Japanese giant salamander, weighing 220 pounds (100 kilograms). Some 370 million years ago the first creatures to leave the seas and walk on land were the amphibians. They pioneered the use of lungs for full-time air breathing, and were the first vertebrates to have true legs, tongues, ears and voice boxes. The increase in body area covered by the nerve cells led to those cells invading the brain: a step to intelligence. Today there are some 4,000 species of amphibian.



The evolution of the pentadactyl *(five-fingered) limb* [A] *can be partly traced through the fossil record. The basic design was already present in lobe-finned fish such as* Eusthenopteron [1]. *Adapting to the terrestrial environment, the limb rotated downward and away from the body. In the first known amphibian,* Ichthyostega [2], *the limb is still compact and the body close to the ground.* Seymouria [3] *developed more extended limbs, which provided greater articulation and ground clearance.*

Despite being cold-blooded, and therefore particularly at the mercy of their environment, amphibians are found on all the continents except Antarctica, from the tropics to north of the Arctic Circle. There are three main groups: the *Urodela* (newts, mudpuppies, sirens and salamanders), the *Anura* (frogs and toads) and the *Gymnophiona* (caecilians or worm lizards). Many features distinguish the amphibians from other vertebrates. They have a three-chambered heart, paired lungs, which are reduced or absent in some salamanders and caecilians, a flattened skull, and teeth that can bend inward.

The breathing body

Unlike reptiles, amphibians have not developed waterproof skins. In fact, many species supplement lung breathing with gas exchange through their skins, which must be kept moist for this purpose. The lining of the mouth is also moist and well supplied with capillaries and can function in gas exchange. A few aquatic salamanders retain their larval external gills in the adult, and a few terrestrial forms have no lungs at all.

The senses also had to adapt to life on land. Eyelids and eye-moistening glands evolved, and true ears (with outer eardrums and two middle-ear bones, neither of which are found in fish ears) for detecting sound vibrations in air. At the same time, the voicebox and vocal sacs evolved – amphibians were the first vertebrates to have a larynx. For the sense of smell, internal nostril openings (*nares*) allow air to be taken into the lungs while the mouth is closed or when only the external nares are above water. This can also help when the amphibian is avoiding land predators.

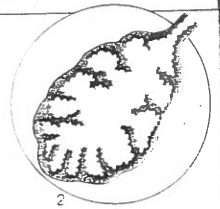
An aquatic inheritance

Amphibians have retained many of their adaptations to the aquatic life. When moving, many amphibians retain an undulating, fish-like motion, except for the frogs and toads, which evolved long hind limbs for hopping on land, or kicking out to swim. Also, many frogs and toads still discharge unfertilized eggs into the water, where sperm is then shed on to them for fertilization to occur.

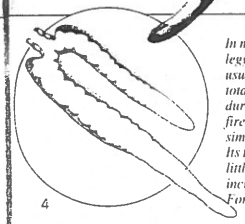
Amphibians have kept their streamlined shape, and many species their webbed feet, for locomotion in water. Their inability to generate internal body heat confines them to the warmer parts of continents, but many species survive considerable cold by reducing their metabolic rates.

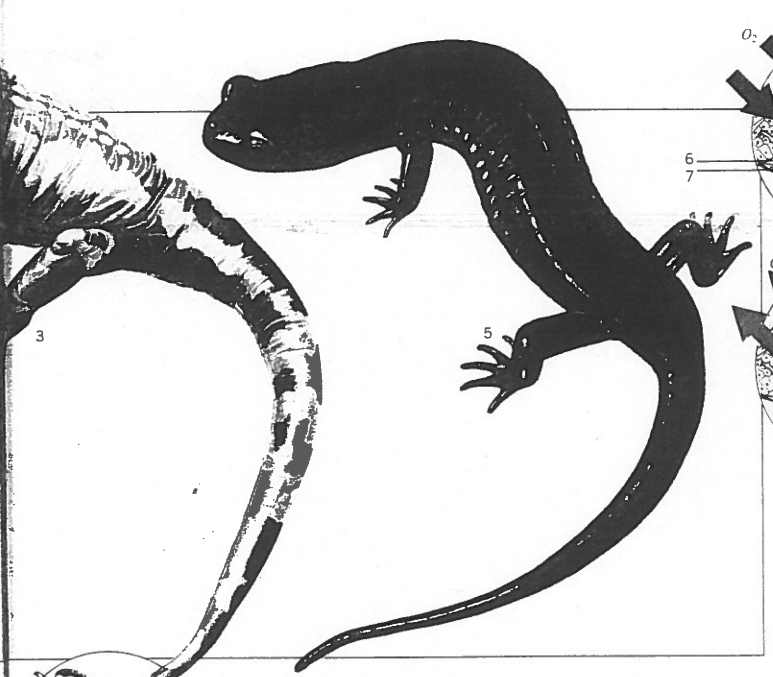
Surviving the desert

Amphibians are relatively common in deserts and other arid regions. They avoid overheating by burrowing in the day and emerging at night. Their main problem is the unpredictable water supply. Certain species can store up to half their body weight of water in the bladder. Some frogs and toads are remarkably tolerant of water loss – the Western spadefoot toad can withstand up to 60 percent reduction in its body water. Another adaptation is to retain urea in the blood, thus permitting the uptake of water by osmosis from even apparently dry soils. Most terrestrial frogs also have a patch of skin rich in blood capillaries in the pelvic region, which takes up water when sitting on damp earth.

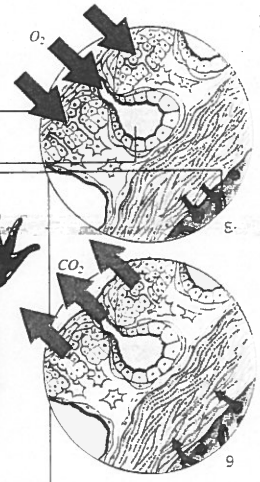


Modern amphibians [B] *display considerable variance in the adaptation of their respiratory systems to the terrestrial environment. Only a few aquatic forms retain their gills when adult. The common frog* [1] *has complex lungs* [2], *with intricate infolding of the vascular cavity walls.*





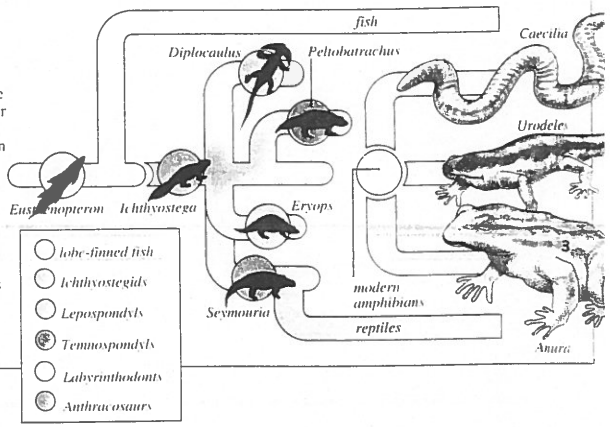
In more advanced four-legged animals the lungs usually provide the animal's total oxygen requirement during active behavior. The fire salamander [3] *has much simpler respiratory organs. Its tubular lungs* [4] *have little infolding with which to increase their surface area. For this reason the lungs can be considered as auxiliary, as oxygen is also obtained through gas exchange over the whole of the body surface. As a result, the fire salamander requires a moist environment and only ventures into the open at night when it is cooler – thereby reducing water loss – and also under very humid conditions. The dusky salamander* [5] *is a* plethodont, *one of a family of lungless salamanders found in North America, for which all respiration takes place through surface gas exchange. This is only possible if the surface is kept moist by secretions from mucous glands* [6].



Exchange takes place via a dense capillary network just below the skin surface [7]. *Dissolved oxygen enters and is absorbed into the blood* [8]. *Carbon dioxide waste from the blood passes out of the body through a reverse process* [9]. *All amphibians make some use of surface exchange. Many frogs can meet their total respiratory requirement in this way while inactive in cool and moist conditions. Surface exchange is much less important to other vertebrates, and is usually insignificant. In humans, for example, surface exchange accounts for less than 1 percent of respiration.*

Missing Links

The first amphibians evolved from lobe-finned fish about 370 million years ago. These fish, like coelacanths, had bony supports in their fins, which might have let them crawl out of the water, and lungs and internal nasal openings for breathing air. The fossil record of amphibians is poor. The earliest amphibians on record, such as *Ichthyostega*, had already evolved hip and shoulder girdles to support the new limbs and ribs to protect the internal organs. One of the largest of them was *Mastodonosaurus*, up to 4 m (13 ft) long. Until the evolution of the dinosaurs, amphibians dominated the land. By about 135 million years ago most were extinct. There are no fossils to link modern amphibians with these ancient forms and no record of the divergence into caecilians [1], newts and salamanders [2], and frogs and toads [3].



Connections: Animals in Heat and Drought 142 Breathing 126 Early Evolution 92 Reptiles 130 Swimming 210

Taking the Air

How animals breathe

Weddell seals have been known to dive underwater for over an hour, but ultimately they must return to the surface for air. Virtually all organisms require oxygen to turn food into energy, and on land this is in plentiful supply thanks to millions of years of photosynthesis by plants, which turns carbon dioxide into oxygen. A watery environment, on the other hand, is poor in oxygen in comparison to air – but to compensate for that, most animals that live in water have a far more efficient means of extracting the oxygen than their air-breathing equivalents.

For most creatures, respiration means absorbing oxygen and disposing of waste carbon dioxide by breathing. Respiration is also the complex process that breaks down fuel molecules to make energy. It usually uses oxygen, but some bacteria can use sulfur.

In a plant or a very small, primitive animal the mechanism may be fairly simple: air comes into direct contact with the cells of the organism, and gas molecules filter through the cell walls by the process known as diffusion. The oxygen diffuses into the cells, the waste gas diffuses out.

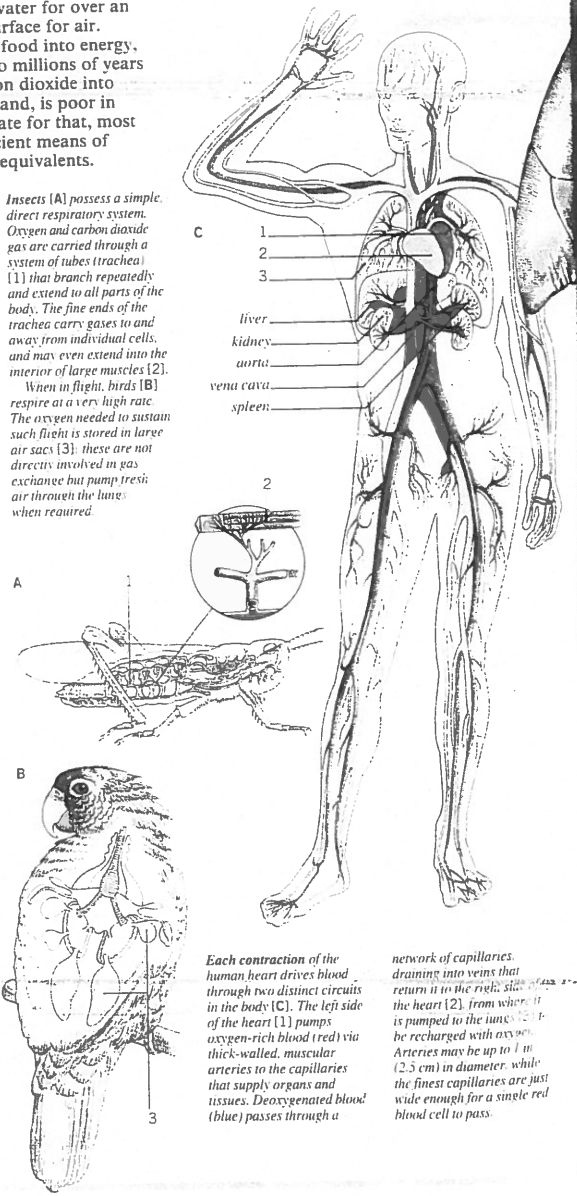
A more complex land animal cannot rely on straightforward diffusion because although it may have a large surface area, a far greater proportion of all its body cells is not in direct contact with the air. Insects have developed the logical solution to the problem: a complex system of branching ducts that carries the air to every part of the body. It works well – but only over short distances: this is one of the reasons why insects have never grown to large sizes.

Mammals, birds, reptiles and many other creatures employ a much more sophisticated arrangement, which exploits the bloodstream as a gas transport system. The oxygen is carried in the red blood cells alongside energy-rich sugars dissolved in the blood plasma. The two are delivered together to each organ, and particularly to the muscles, for storage or for instant use. When the energy in the sugars has been released by oxidation, the blood carries away the waste carbon dioxide.

The blood collects oxygen – and gets rid of carbon dioxide – by flowing through a gas exchanger. In air-breathing animals this is a lung: an air-filled cavity lined with very fine blood vessels (capillaries) that have walls so thin as to allow the flow of gases – but not liquid – through them. As the blood is pumped through the capillaries, carbon dioxide diffuses out into the air and oxygen diffuses in. The oxygenated blood flows away to transport its oxygen to the rest of the body.

Expansion and contraction

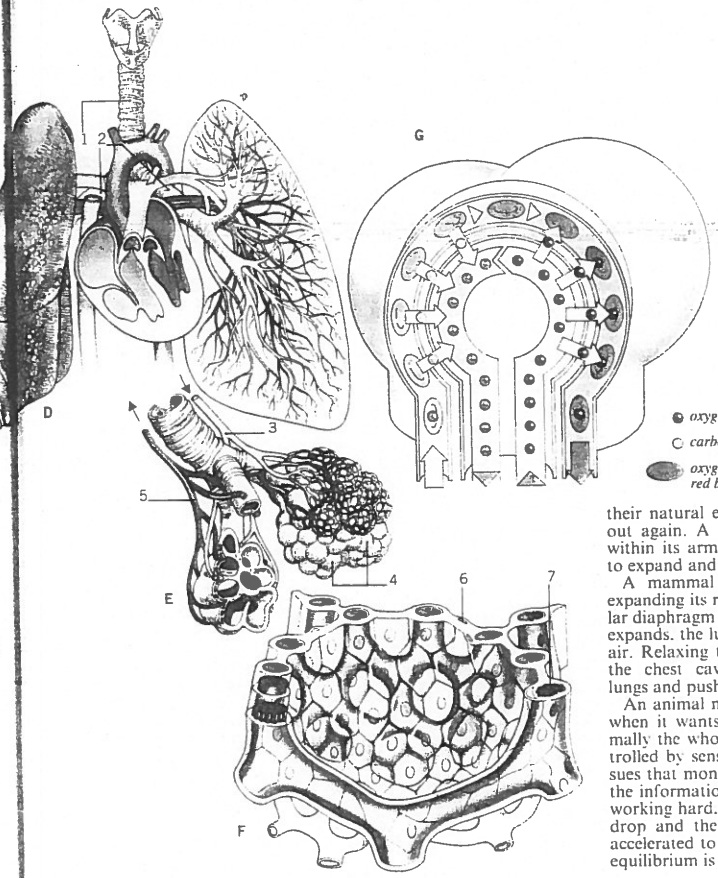
Some small animals rely on diffusion through their external surface to refresh the oxygen supply in their lungs, but larger animals actively pump the air in and out. A frog raises the floor of its mouth to squeeze a mouthful of fresh air into its inflatable lungs, relying on



Insects [A] *possess a simple, direct respiratory system. Oxygen and carbon dioxide gas are carried through a system of tubes (trachea)* [1] *that branch repeatedly and extend to all parts of the body. The fine ends of the trachea carry gases to and away from individual cells, and may even extend into the interior of large muscles* [2].

When in flight, birds [B] *respire at a very high rate. The oxygen needed to sustain such flight is stored in large air sacs* [3]; *these are not directly involved in gas exchange but pump fresh air through the lungs when required.*

***Each contraction** of the human heart drives blood through two distinct circuits in the body* [C]. *The left side of the heart* [1] *pumps oxygen-rich blood (red) via thick-walled, muscular arteries to the capillaries that supply organs and tissues. Deoxygenated blood (blue) passes through a network of capillaries, draining into veins that return it to the right side of the heart* [2], *from where it is pumped to the lungs to be recharged with oxygen. Arteries may be up to 1 in (2.5 cm) in diameter, while the finest capillaries are just wide enough for a single red blood cell to pass.*



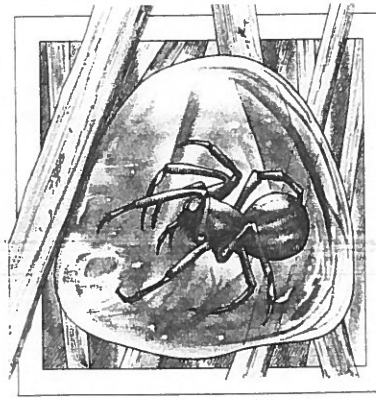
Gas exchange [G] *takes place across the thin, moist alveolar wall. According to the laws of physical diffusion, gases pass from a higher concentration to areas of lower concentration. So, as fresh air enters the alveolar sac, oxygen diffuses into the bloodstream, where it is rapidly bound by the disklike red blood cells. Any waste carbon dioxide is released by the red blood cells into the sac, after which it is exhaled.*

The lungs [D] *provide a large surface area over which gas exchange can occur. Inhaled air is drawn through the trachea* [1], *which divides into two bronchi* [2]. *On entering the lungs the bronchi branch repeatedly, eventually leading to blind-ending sacs* [E], *surrounded by a web of vessels that carry deoxygenated, carbon dioxide-rich blood* [3] *to the bulblike alveoli* [4] *and oxygenated blood* [5] *back to the heart. Each alveolus* [F] *has walls just one cell thick* [6], *to separate the capillaries from the air within. The alveoli are supported by a framework of connective tissue* [7].

their natural elasticity to force the spent air out again. A tortoise has powerful muscles within its armored body that force its lungs to expand and contract.

A mammal enlarges its chest cavity by expanding its ribcage and lowering the muscular diaphragm beneath its lungs. As the cavity expands, the lungs expand with it, drawing in air. Relaxing the ribs and diaphragm makes the chest cavity smaller, compressing the lungs and pushing the air out.

An animal may consciously hold its breath when it wants to dive underwater, but normally the whole system is automatically controlled by sense organs in the blood and tissues that monitor oxygen levels and transmit the information to the brain. If the animal is working hard, it uses oxygen faster: the levels drop and the breathing and heart rate are accelerated to build them up once more until equilibrium is restored.



A Personal Air Supply

Most aquatic animals are able to get their oxygen directly from the water, but some have to breathe air. Many of these simply return to the surface at intervals to take a gulp of air before diving again, but the water spider carries a personal air supply, much as a human diver does with an aqualung. In this way it avoids expending energy on trips to the surface and reduces its exposure to aerial and aquatic predators.

The air is trapped by fine hairs to form a silvery bubble around the spider's body. The spider simply breathes the air in the bubble. If the surrounding water contains plenty of dissolved oxygen, this finds its way into the bubble; in this fashion the spider is never in any danger of running short of the air it needs. The creature even builds its nest underwater, rearing its young inside an air bubble lodged among the water plants.

Connections: Atmosphere 64 Cycles of Life 206 Early Evolution 92 Fish 124 Mammals 136 Photosynthesis 182

Taking the Air

How animals breathe

Weddell seals have been known to dive underwater for over an hour, but ultimately they must return to the surface for air. Virtually all organisms require oxygen to turn food into energy, and on land this is in plentiful supply thanks to millions of years of photosynthesis by plants, which turns carbon dioxide into oxygen. A watery environment, on the other hand, is poor in oxygen in comparison to air – but to compensate for that, most animals that live in water have a far more efficient means of extracting the oxygen than their air-breathing equivalents.

For most creatures, respiration means absorbing oxygen and disposing of waste carbon dioxide by breathing. Respiration is also the complex process that breaks down fuel molecules to make energy. It usually uses oxygen, but some bacteria can use sulfur.

In a plant or a very small, primitive animal the mechanism may be fairly simple: air comes into direct contact with the cells of the organism, and gas molecules filter through the cell walls by the process known as diffusion. The oxygen diffuses into the cells, the waste gas diffuses out.

A more complex land animal cannot rely on straightforward diffusion because although it may have a large surface area, a far greater proportion of all its body cells is not in direct contact with the air. Insects have developed the logical solution to the problem: a complex system of branching ducts that carries the air to every part of the body. It works well – but only over short distances: this is one of the reasons why insects have never grown to large sizes.

Mammals, birds, reptiles and many other creatures employ a much more sophisticated arrangement, which exploits the bloodstream as a gas transport system. The oxygen is carried in the red blood cells alongside energy-rich sugars dissolved in the blood plasma. The two are delivered together to each organ, and particularly to the muscles, for storage or for instant use. When the energy in the sugars has been released by oxidation, the blood carries away the waste carbon dioxide.

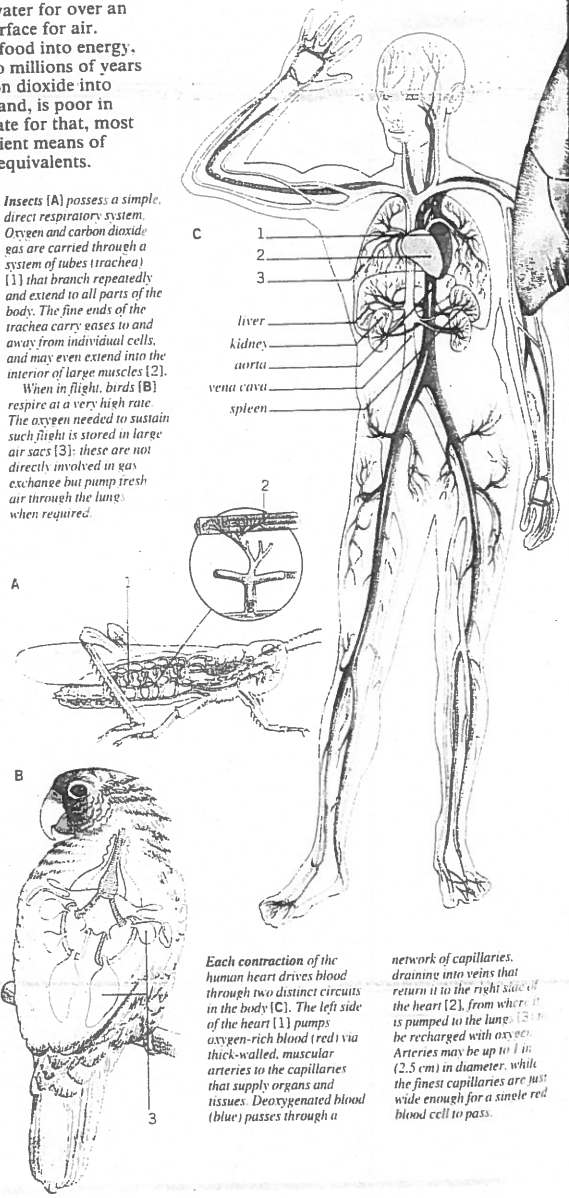
The blood collects oxygen – and gets rid of carbon dioxide – by flowing through a gas exchanger. In air-breathing animals this is a lung: an air-filled cavity lined with very fine blood vessels (capillaries) that have walls so thin as to allow the flow of gases – but not liquid – through them. As the blood is pumped through the capillaries, carbon dioxide diffuses out into the air and oxygen diffuses in. The oxygenated blood flows away to transport its oxygen to the rest of the body.

Expansion and contraction

Some small animals rely on diffusion through their external surface to refresh the oxygen supply in their lungs, but larger animals actively pump the air in and out. A frog raises the floor of its mouth to squeeze a mouthful of fresh air into its inflatable lungs, relying on their natural elasticity to force the spent air out again. A tortoise has powerful muscles within its armored body that force its lungs to expand and contract.

A mammal enlarges its chest cavity by expanding its ribcage and lowering the muscular diaphragm beneath its lungs. As the cavity expands, the lungs expand with it, drawing in air. Relaxing the ribs and diaphragm makes the chest cavity smaller, compressing the lungs and pushing the air out.

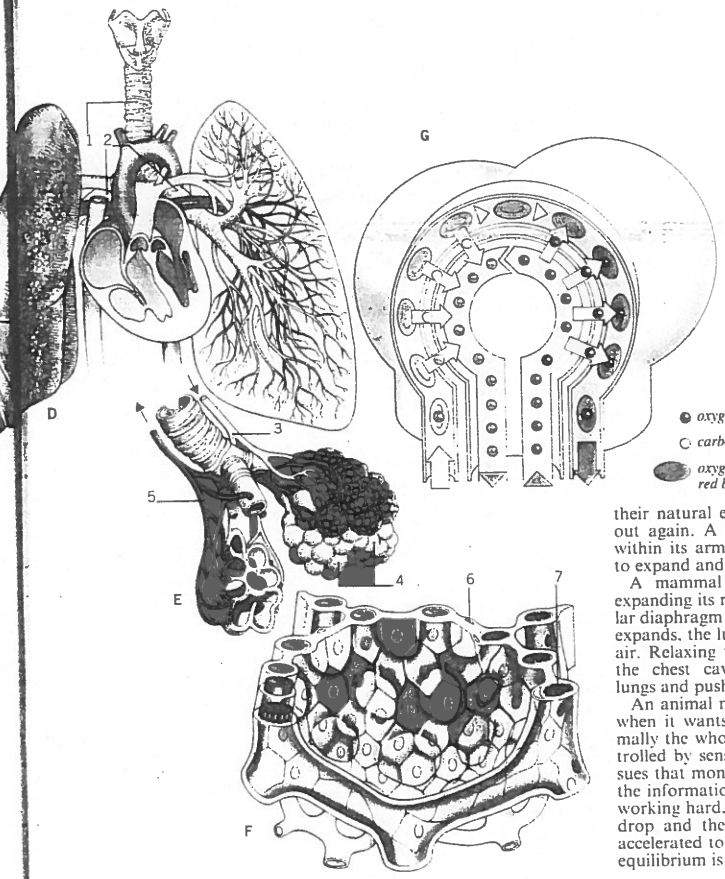
An animal may consciously hold its breath when it wants to dive underwater, but normally the whole system is automatically controlled by sense organs in the blood and tissues that monitor oxygen levels and transmit the information to the brain. If the animal is working hard, it uses oxygen faster: the levels drop and the breathing and heart rate are accelerated to build them up once more until equilibrium is restored.



Insects **(A)** *possess a simple, direct respiratory system. Oxygen and carbon dioxide gas are carried through a system of tubes (trachea)* **(1)** *that branch repeatedly and extend to all parts of the body. The fine ends of the trachea carry gases to and away from individual cells, and may even extend into the interior of large muscles* **(2)**.

When in flight, birds **(B)** *respire at a very high rate. The oxygen needed to sustain such flight is stored in large air sacs* **(3)**: *these are not directly involved in gas exchange but pump fresh air through the lungs when required.*

Each contraction of the human heart drives blood through two distinct circuits in the body **(C)**. *The left side of the heart* **(1)** *pumps oxygen-rich blood (red) via thick-walled, muscular arteries to the capillaries that supply organs and tissues. Deoxygenated blood (blue) passes through a network of capillaries, draining into veins that return it to the right side of the heart* **(2)**, *from where it is pumped to the lungs* **(3)** *to be recharged with oxygen. Arteries may be up to 1 in (2.5 cm) in diameter, while the finest capillaries are just wide enough for a single red blood cell to pass.*



Gas exchange **(G)** *takes place across the thin, moist alveolar wall. According to the laws of physical diffusion, gases pass from a higher concentration to areas of lower concentration. So, as fresh air enters the alveolar sac, oxygen diffuses into the bloodstream, where it is rapidly bound by the disklike red blood cells. Any waste carbon dioxide is released by the red blood cells into the sac, after which it is exhaled.*

The lungs **(D)** *provide a large surface area over which gas exchange can occur. Inhaled air is drawn through the trachea* **(1)**, *which divides into two bronchi* **(2)**. *On entering the lungs the bronchi branch repeatedly, eventually leading to blind-ending sacs* **(E)**, *surrounded by a web of vessels that carry deoxygenated, carbon dioxide-rich blood* **(3)** *to the bulblike alveoli* **(4)** *and oxygenated blood* **(5)** *back to the heart. Each alveolus* **(F)** *has walls just one cell thick* **(6)**, *to separate the capillaries from the air within. The alveoli are supported by a framework of connective tissue* **(7)**.

A Personal Air Supply

Most aquatic animals are able to get their oxygen directly from the water, but some have to breathe air. Many of these simply return to the surface at intervals to take a gulp of air before diving again, but the water spider carries a personal air supply, much as a human diver does with an aqualung. In this way it avoids expending energy on trips to the surface and reduces its exposure to aerial and aquatic predators.

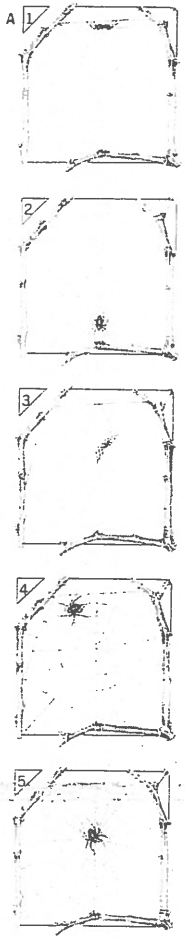
The air is trapped by fine hairs to form a silvery bubble around the spider's body. The spider simply breathes the air in the bubble. If the surrounding water contains plenty of dissolved oxygen, this finds its way into the bubble; in this fashion the spider is never in any danger of running short of the air it needs. The creature even builds its nest underwater, rearing its young inside an air bubble lodged among the water plants.

Connections: Atmosphere 64 Cycles of Life 206 Early Evolution 92 Fish 124 Mammals 136 Photosynthesis 182

Architects in Silk

How spiders spin and use webs

Spider silk is one of the strongest natural substances known. A single thread of it can be stretched by nearly a third without snapping, and would have to be about 50 miles (80 kilometers) long to break purely under its own weight. With the silk secreted by their glands, spiders build an enormous variety of webs, from flimsy hammocks to delicate spirals within spirals, sticky sheets and thick funnels. They also use their silk to wrap up prey, to cocoon eggs, and even in mating, when the male enfolds its sperm in a miniweb, which it places inside the female.



Spiders produce their silk as a fluid containing a protein called *fibroin*. This solidifies into an insoluble thread when the proteins rearrange themselves under tension as the silk is drawn out of the spider's body. Spiders have several glands to make silks for different uses – as draglines attached to a fixed point by silken suction disks, as prey-catching spirals, and as wrapping for prey, cocoons, eggs, or sperm. The silk used to make structures such as cocoons and draglines is dry, but threads used to trap prey are often sticky. The Australian bolas spider spins a special strand of silk that it uses in a unique way. The thread ends in a small ball (the *bolas*), which is coated with female moth pheromones. Male moths are attracted to the ball, but end up trapped on the sticky thread.

Weaving webs

Spiders' webs range in complexity from apparently chaotic tangles of threads to dense sheets, tubes, and the intricate, highly organized orb web of species such as the familiar garden spiders.

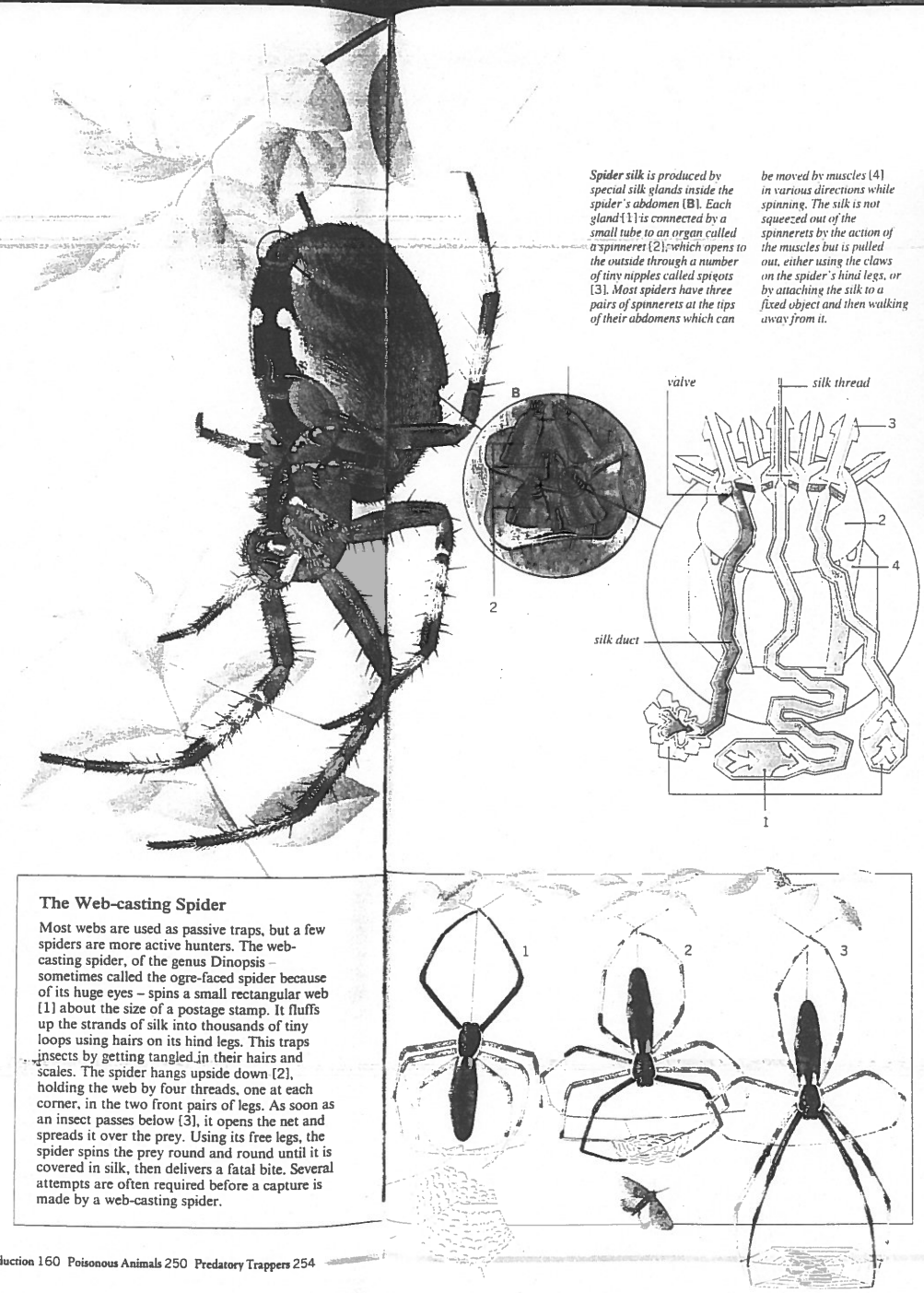
Webs spun above the ground require some sort of scaffolding: a framework of threads anchored to rocks, vegetation, or other solid structures. This framework may be surprisingly large in relation to the size of the spider. The spider selects a high perch, and allows a line of silk to float on the air until it touches and sticks to some object. Other threads can be spun from this base line. Within the framework, a denser meshwork of threads is spun to trap the prey. In the orb web, this takes the form of a spiral of sticky silk. When the spider has laid down a section of sticky silk, it jerks the thread sharply, causing the glue to form a series of blobs along the thread, which are very effective in trapping prey. Although the sticky thread traps insects, the spider is able to walk around its web without difficulty. It walks only on the dry threads, and uses special brushes on its claws to grip the fine silk threads. An oily coating on its feet helps to prevent them from sticking if it accidentally encounters the glue.

Web wonders

Experiments have shown that construction of the web is purely instinctive, controlled by touch. Each successive step is triggered by the position of existing threads and the degree of tension on them. Newly hatched spiderlings can spin a perfect orb web first time.

Spiders are extremely sensitive to touch and vibration. Once an insect blunders into the web, the spider can tell exactly where it is by the tension and vibrations of the various threads that it disturbs. Courting male spiders, which are usually much smaller than females, vibrate the web in a special way to signal they are prospective mates, not meals.

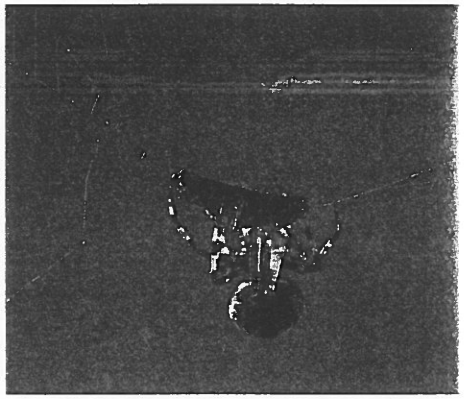
When spinning its web (A), *the spider first casts out a thread of silk to form a horizontal strut* (1), *which it then reinforces to form a bridge-line. A second, drooping thread is trailed across below the bridge-line. Halfway along the second thread, the spider drops down on a vertical thread until it reaches a fixed object* (2). *It pulls the silk taut and anchors it, forming a "Y" shape, the center of which forms the hub of the web. The spider then spins the framework threads and the radials, which are linked together at the hub* (3). *After spinning the remainder of the radials, a wide temporary spiral of dry silk is laid down, working from the inside of the web outward* (4). *This holds the web together while the spider lays down the sticky spiral. This is laid down starting from the outside, and is attached successively to each radial thread* (5). *The spider eats the remains of the dry spiral as it proceeds. The central dry spirals are left as a platform for the spider, which will often lie in wait there during the night, but will retreat to a nearby silk shelter during the day. Spiders tend to spin their webs at night, when they are less likely to attract the attention of birds. Most orb spiders need to spin a new web every night, and they eat the old one to save the protein.*



Spider silk is produced by special silk glands inside the spider's abdomen (B). *Each gland* (1) *is connected by a small tube to an organ called a spinneret* (2), *which opens to the outside through a number of tiny nipples called spigots* (3). *Most spiders have three pairs of spinnerets at the tips of their abdomens which can be moved by muscles* (4) *in various directions while spinning. The silk is not squeezed out of the spinnerets by the action of the muscles but is pulled out, either using the claws on the spider's hind legs, or by attaching the silk to a fixed object and then walking away from it.*

The Web-casting Spider

Most webs are used as passive traps, but a few spiders are more active hunters. The web-casting spider, of the genus Dinopsis – sometimes called the ogre-faced spider because of its huge eyes – spins a small rectangular web (1) about the size of a postage stamp. It fluffs up the strands of silk into thousands of tiny loops using hairs on its hind legs. This traps insects by getting tangled in their hairs and scales. The spider hangs upside down (2), holding the web by four threads, one at each corner, in the two front pairs of legs. As soon as an insect passes below (3), it opens the net and spreads it over the prey. Using its free legs, the spider spins the prey round and round until it is covered in silk, then delivers a fatal bite. Several attempts are often required before a capture is made by a web-casting spider.



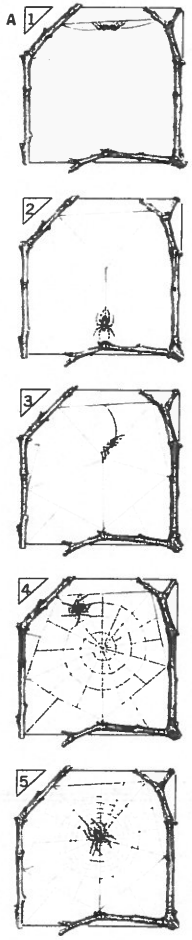
The successful hunter (above) *spins a straitjacket of silk around a trapped insect to prevent its escape. Spiders frequently enfold relatively large prey in this way while they attempt to bite them and inflict a paralyzing poison. Once paralyzed, the prey can be unwrapped and eaten, or saved for later. Spiders usually walk on the underside of their own webs, dangling by their claws, to keep their bodies from coming into contact with the sticky spirals of thread.*

Connections: Breathing 126 Invertebrate Carnivores 200 Invertebrates 122 Invertebrate Reproduction 160 Poisonous Animals 250 Predatory Trappers 254

Architects in Silk

How spiders spin and use webs

Spider silk is one of the strongest natural substances known. A single thread of it can be stretched by nearly a third without snapping, and would have to be about 50 miles (80 kilometers) long to break purely under its own weight. With the silk secreted by their glands, spiders build an enormous variety of webs, from flimsy hammocks to delicate spirals within spirals, sticky sheets and thick funnels. They also use their silk to wrap up prey, to cocoon eggs, and even in mating, when the male enfolds its sperm in a miniweb, which it places inside the female.



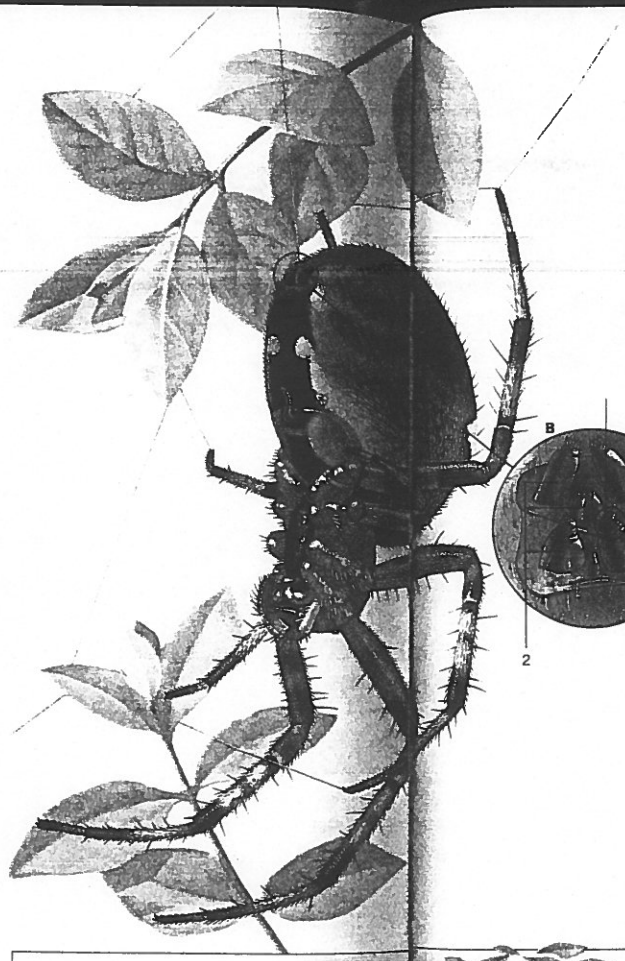
Spiders produce their silk as a fluid containing a protein called *fibroin*. This solidifies into an insoluble thread when the proteins rearrange themselves under tension as the silk is drawn out of the spider's body. Spiders have several glands to make silks for different uses – as draglines attached to a fixed point by silken suction disks, as prey-catching spirals, and as wrapping for prey, cocoons, eggs, or sperm. The silk used to make structures such as cocoons and draglines is dry, but threads used to trap prey are often sticky. The Australian bolas spider spins a special strand of silk that it uses in a unique way. The thread ends in a small ball (the *bolas*), which is coated with female moth pheromones. Male moths are attracted to the ball, but end up trapped on the sticky thread.

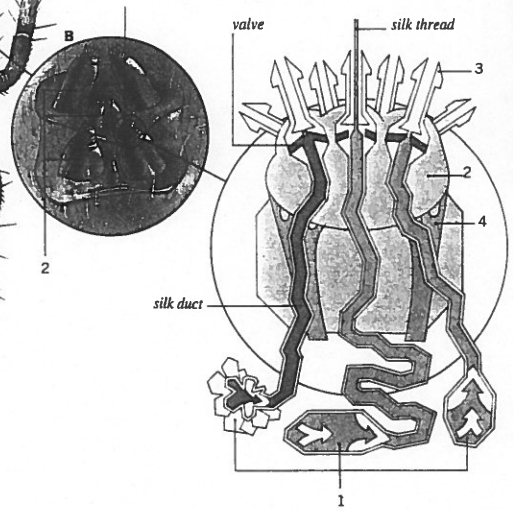
Weaving webs

Spiders' webs range in complexity from apparently chaotic tangles of threads to dense sheets, tubes, and the intricate, highly organized orb web of species such as the familiar garden spiders.

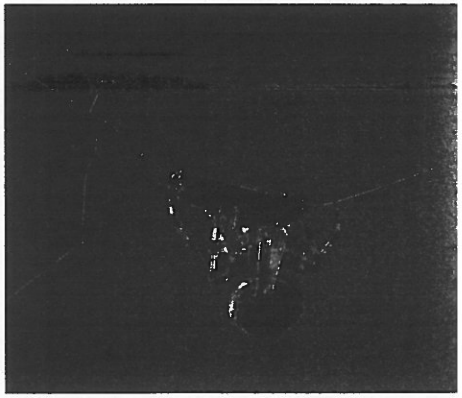
Webs spun above the ground require some sort of scaffolding: a framework of threads anchored to rocks, vegetation, or other solid structures. This framework may be surprisingly large in relation to the size of the spider. The spider selects a high perch, and allows a line of silk to float on the air until it touches and sticks to some object. Other threads can be spun from this base line. Within the framework, a denser meshwork of threads is spun to trap the prey. In the orb web, this takes the form of a spiral of sticky silk. When the spider has laid down a section of sticky silk, it jerks the thread sharply, causing the glue to form a series of blobs along the thread, which are very effective in trapping prey. Although the sticky thread traps insects, the spider is able to walk around its web without difficulty. It walks only on the dry threads, and uses special brushes on its claws to grip the fine silk threads. An oily coating on its feet helps to prevent them from sticking if it accidentally encounters the glue.

When spinning its web *[A], the spider first casts out a thread of silk to form a horizontal strut [1], which it then reinforces to form a bridge-line. A second, drooping thread is trailed across below the bridge-line. Halfway along the second thread, the spider drops down on a vertical thread until it reaches a fixed object [2]. It pulls the silk taut and anchors it, forming a "Y" shape, the center of which forms the hub of the web. The spider then spins the framework threads and the radials, which are linked together at the hub [3]. After spinning the remainder of the radials, a wide temporary spiral of dry silk is laid down, working from the inside of the web outward [4]. This holds the web together while the spider lays down the sticky spiral. This is laid down starting from the outside, and is attached successively to each radial thread [5]. The spider eats the remains of the dry spiral as it proceeds. The central dry spirals are left as a platform for the spider, which will often lie in wait there during the night, but will retreat to a nearby silk shelter during the day. Spiders tend to spin their webs at night, when they are less likely to attract the attention of birds. Most orb spiders need to spin a new web every night, and they eat the old one to save the protein.*





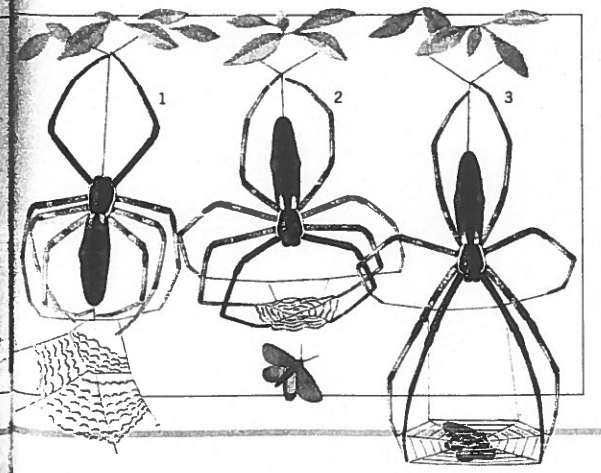
Spider silk *is produced by special silk glands inside the spider's abdomen [B]. Each gland [1] is connected by a small tube to an organ called a spinneret [2], which opens to the outside through a number of tiny nipples called spigots [3]. Most spiders have three pairs of spinnerets at the tips of their abdomens which can be moved by muscles [4] in various directions while spinning. The silk is not squeezed out of the spinnerets by the action of the muscles but is pulled out, either using the claws on the spider's hind legs, or by attaching the silk to a fixed object and then walking away from it.*



The successful hunter *(above) spins a straitjacket of silk around a trapped insect to prevent its escape. Spiders frequently enfold relatively large prey in this way while they attempt to bite them and inflict a paralyzing poison. Once paralyzed, the prey can be unwrapped and eaten, or saved for later. Spiders usually walk on the underside of their own webs, dangling by their claws, to keep their bodies from coming into contact with the sticky spirals of thread.*

The Web-casting Spider

Most webs are used as passive traps, but a few spiders are more active hunters. The web-casting spider, of the genus Dinopsis – sometimes called the ogre-faced spider because of its huge eyes – spins a small rectangular web [1] about the size of a postage stamp. It fluffs up the strands of silk into thousands of tiny loops using hairs on its hind legs. This traps insects by getting tangled in their hairs and scales. The spider hangs upside down [2], holding the web by four threads, one at each corner, in the two front pairs of legs. As soon as an insect passes below [3], it opens the net and spreads it over the prey. Using its free legs, the spider spins the prey round and round until it is covered in silk, then delivers a fatal bite. Several attempts are often required before a capture is made by a web-casting spider.



Web wonders

Experiments have shown that construction of the web is purely instinctive, controlled by touch. Each successive step is triggered by the position of existing threads and the degree of tension on them. Newly hatched spiderlings can spin a perfect orb web first time.

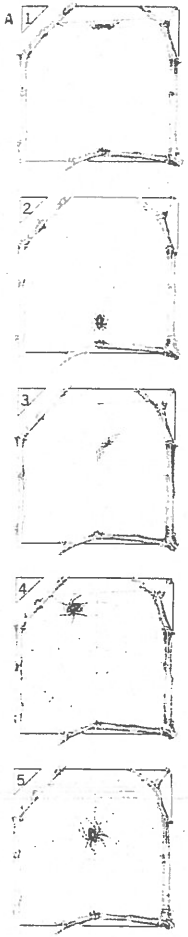
Spiders are extremely sensitive to touch and vibration. Once an insect blunders into the web, the spider can tell exactly where it is by the tension and vibrations of the various threads that it disturbs. Courting male spiders, which are usually much smaller than females, vibrate the web in a special way to signal they are prospective mates, not meals.

Connections: Breathing 126 Invertebrate Carnivores 200 Invertebrates 122 Invertebrate Reproduction 160 Poisonous Animals 250 Predatory Trappers 254

Architects in Silk

How spiders spin and use webs

Spider silk is one of the strongest natural substances known. A single thread of it can be stretched by nearly a third without snapping, and would have to be about 50 miles (80 kilometers) long to break purely under its own weight. With the silk secreted by their glands, spiders build an enormous variety of webs, from flimsy hammocks to delicate spirals within spirals, sticky sheets and thick funnels. They also use their silk to wrap up prey, to cocoon eggs, and even in mating, when the male enfolds its sperm in a miniweb, which it places inside the female.



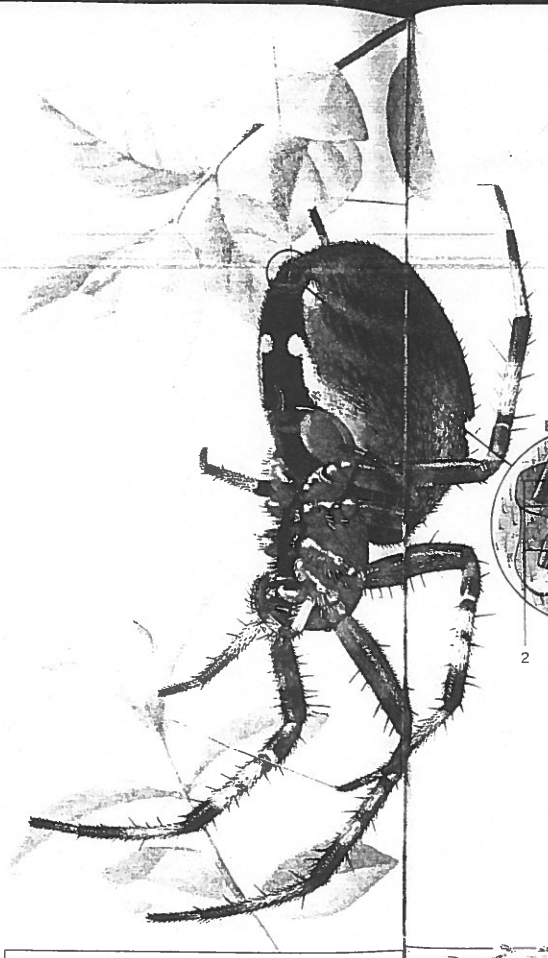
Spiders produce their silk as a fluid containing a protein called *fibroin*. This solidifies into an insoluble thread when the proteins rearrange themselves under tension as the silk is drawn out of the spider's body. Spiders have several glands to make silks for different uses – as draglines attached to a fixed point by silken suction disks, as prey-catching spirals, and as wrapping for prey, cocoons, eggs, or sperm. The silk used to make structures such as cocoons and draglines is dry, but threads used to trap prey are often sticky. The Australian bolas spider spins a special strand of silk that it uses in a unique way. The thread ends in a small ball (the *bolas*), which is coated with female moth pheromones. Male moths are attracted to the ball, but end up trapped on the sticky thread.

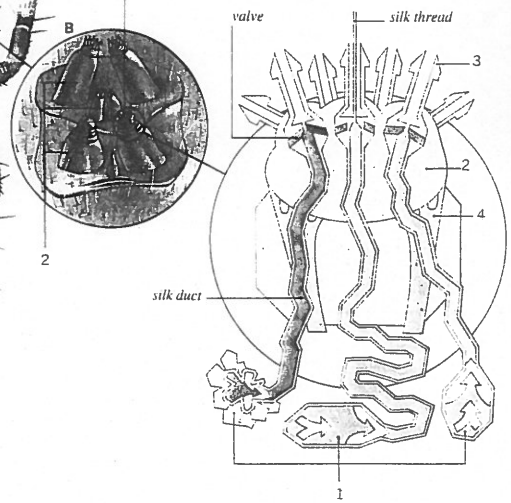
Weaving webs

Spiders' webs range in complexity from apparently chaotic tangles of threads to dense sheets, tubes, and the intricate, highly organized orb web of species such as the familiar garden spiders.

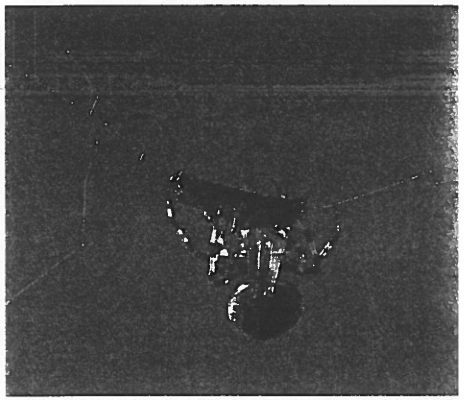
Webs spun above the ground require some sort of scaffolding: a framework of threads anchored to rocks, vegetation, or other solid structures. This framework may be surprisingly large in relation to the size of the spider. The spider selects a high perch, and allows a line of silk to float on the air until it touches and sticks to some object. Other threads can be spun from this base line. Within the framework, a denser meshwork of threads is spun to trap the prey. In the orb web, this takes the form of a spiral of sticky silk. When the spider has laid down a section of sticky silk, it jerks the thread sharply, causing the glue to form a series of blobs along the thread, which are very effective in trapping prey. Although the sticky thread traps insects, the spider is able to walk around its web without difficulty. It walks only on the dry threads, and uses special brushes on its claws to grip the fine silk threads. An oily coating on its feet helps to prevent them from sticking if it accidentally encounters the glue.

When spinning its web *(A), the spider first casts out a thread of silk to form a horizontal strut (1), which it then reinforces to form a bridge-line. A second, drooping thread is trailed across below the bridge-line. Halfway along the second thread, the spider drops down on a vertical thread until it reaches a fixed object (2). It pulls the silk taut and anchors it, forming a "Y" shape, the center of which forms the hub of the web. The spider then spins the framework threads and the radials, which are linked together at the hub (3). After spinning the remainder of the radials, a wide temporary spiral of dry silk is laid down, working from the inside of the web outward (4). This holds the web together while the spider lays down the sticky spiral. This is laid down starting from the outside, and is attached successively to each radial thread (5). The spider eats the remains of the dry spiral as it proceeds. The central dry spirals are left as a platform for the spider, which will often lie in wait there during the night, but will retreat to a nearby silk shelter during the day. Spiders tend to spin their webs at night, when they are less likely to attract the attention of birds. Most orb spiders need to spin a new web every night, and they eat the old one to save the protein.*





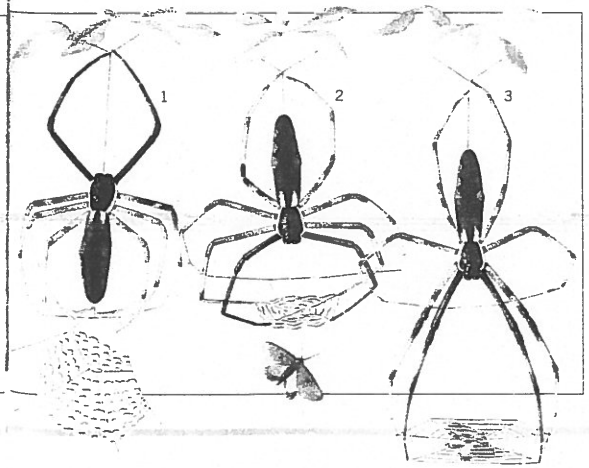
Spider silk *is produced by special silk glands inside the spider's abdomen (B). Each gland (1) is connected by a small tube to an organ called a spinneret (2), which opens to the outside through a number of tiny nipples called spigots (3). Most spiders have three pairs of spinnerets at the tips of their abdomens which can be moved by muscles (4) in various directions while spinning. The silk is not squeezed out of the spinnerets by the action of the muscles but is pulled out, either using the claws on the spider's hind legs, or by attaching the silk to a fixed object and then walking away from it.*



The successful hunter *(above) spins a straitjacket of silk around a trapped insect to prevent its escape. Spiders frequently enfold relatively large prey in this way while they attempt to bite them and inflict a paralyzing poison. Once paralyzed, the prey can be unwrapped and eaten, or saved for later. Spiders usually walk on the underside of their own webs, dangling by their claws, to keep their bodies from coming into contact with the sticky spirals of thread.*

The Web-casting Spider

Most webs are used as passive traps, but a few spiders are more active hunters. The web-casting spider, of the genus Dinopsis – sometimes called the ogre-faced spider because of its huge eyes – spins a small rectangular web (1) about the size of a postage stamp. It fluffs up the strands of silk into thousands of tiny loops using hairs on its hind legs. This traps insects by getting tangled in their hairs and scales. The spider hangs upside down (2), holding the web by four threads, one at each corner, in the two front pairs of legs. As soon as an insect passes below (3), it opens the net and spreads it over the prey. Using its free legs, the spider spins the prey round and round until it is covered in silk, then delivers a fatal bite. Several attempts are often required before a capture is made by a web-casting spider.



Web wonders

Experiments have shown that construction of the web is purely instinctive, controlled by touch. Each successive step is triggered by the position of existing threads and the degree of tension on them. Newly hatched spiderlings can spin a perfect orb web first time.

Spiders are extremely sensitive to touch and vibration. Once an insect blunders into the web, the spider can tell exactly where it is by the tension and vibrations of the various threads that it disturbs. Courting male spiders, which are usually much smaller than females, vibrate the web in a special way to signal they are prospective mates, not meals.

Connections: Breathing 126 Invertebrate Carnivores 200 Invertebrates 122 Invertebrate Reproduction 160 Poisonous Animals 250 Predatory Trappers 254

Indian Dances and Costumes by William K. Powers
©1966 G. P. Putnam's Sons NY

XVI

The Buffalo Dance

Old Indians speak of the buffalo with great respect. It was the main source of life for the plains Indian, and he believed that the buffalo was a messenger of the great Spirit sent down to the earth people to provide all of their necessities. How true it was. The great shaggy beasts provided not only meat and soup, warm robes and moccasins, parfleche and tipis — there were hundreds of additional uses of the buffalo.

The buffalo provided marrow for treating wounds or for making paint, horns for musical instruments or cooking ladles, and ribs for children to use as sleds. Buffalo hair was used to stuff dolls. The animal's stomach was cleaned and used as a cooking pot. The sinew was used for sewing. No part of the buffalo was wasted.

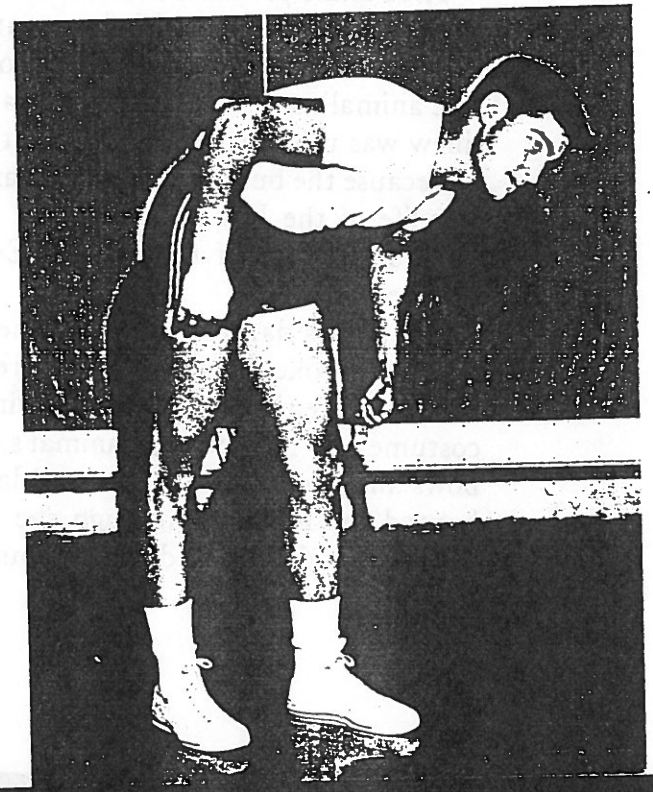
Because the buffalo played such an important part in the everyday life of the Indian, there were many songs and dances performed in honor of the buffalo. Every tribe had some form of tribute.

Sometimes dances were performed before leaving on a buffalo hunt, to invoke the power of the great beast. In these dances, the hunters wore the shaggy buffaloskin robes and buffalo horns as a costume and imitated the animal's movements. They carried the bows and arrows, the lances, and later the guns with which they hunted the buffalo. Although the days of the buffalo hunt are gone, the Indians still dance the buffalo dance. The dance as it is

Black Bear, c
ing a buffalc
and horns c
dance the bu
tumes. (Photc

During
move ab

Black Bear, a Sioux Indian from South Dakota, wearing a buffalo-dance headdress made from the head and horns of a buffalo. Nowadays, Plains Indians dance the buffalo dance in standard war-dance costumes. (Photo: Bell.)



During the thunder-drumming, the dancers move about imitating the actions of buffalo.

described here is performed by the southern-plains tribes of Oklahoma at their Annual Exposition. Traditionally, it follows the snake dance.

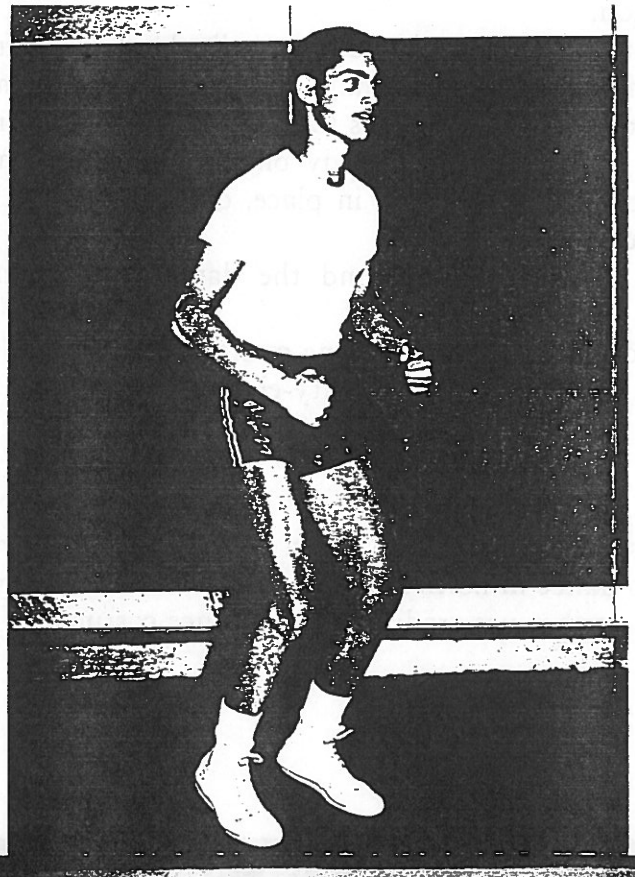
Drumming and Song

Both thunder-drumming and a steady beat are used in the buffalo dance. The steady beat is the one-quarter beat played half-time at ♩ =60. A recording of the buffalo-dance song can be found on American Indian Soundchiefs (*Kiowa Buffalo Dance*, sung by White Fox). Although the song is labeled Kiowa, the Comanche claim to be the rightful owners and originators of the dance.

The Buffalo-Dance Steps

There are two movements in the buffalo dance that correspond with the thunder-drumming and the one-quarter beat.

During the one-quarter beat, the dancers stand in place and perform the jump step.



During the thunder-drumming, the dancers scatter over the dance area, each one going in his own direction, moving his head from side to side as if he were a buffalo milling about on the prairie. Sometimes, the dancers brush up against each other slightly, imitating the movements of the buffalo.

During the one-quarter beat, the dancers stand in place and perform the following jump step:

Assume the Indian stance, but bend both knees slightly. On each beat of the drum, jump, so that both feet come down on each beat of the drum. Your hands are on your hips. The action should be absorbed from the waist down, so that your head "stays in place" as you jump. These jumps are done in place or in a small semicircle, as you move to your right and then to your left. You may also take a few steps forward between jump steps, bending your head low.

The Dance

The buffalo dance begins at the conclusion of the snake dance. The dancers take their place on the dance area, scattering in every direction.

The drum thunders, and the dancers walk about, imitating the movement of the buffalo, bending their heads low, or moving them from side to side. This lasts for about forty-five seconds.

The drum changes to the steady one-quarter time, and the dancers perform the jump step in place, dancing in small semicircles for fourteen beats.

The drum thunders again, and the dancers begin walking about.

Again the drum changes to the one-quarter time, and the dancers perform the jump step for twenty-eight beats.

The entire sequence is then repeated again.

Costumes

Although some of the southwestern tribes dance their version of the buffalo dance in horned bonnets and buffalo-skin leggings, the Oklahoma tribes use traditional war-dance costumes.

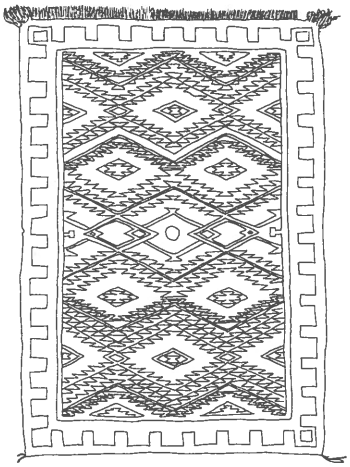
A Page for Discovery

Eye Dazzlers: The Work of Navajo Weavers

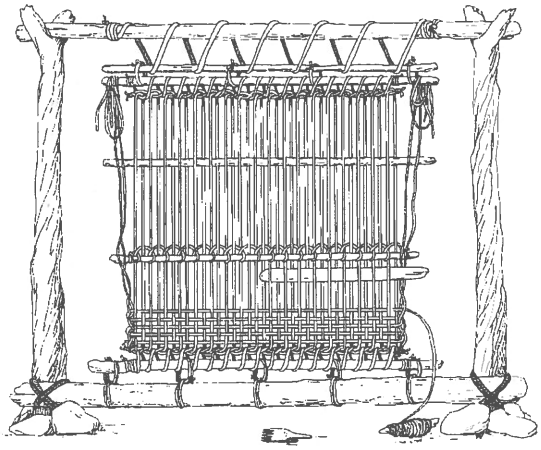
Amy E. Halpin
Technical Assistant in Anthropology
Blanket Drawings by Karen McCarter Lommler

Vibrating designs in a wide range of intense colors and complex patterns first appeared about a century ago among the Navajo weavers. Coined **Eye-Dazzlers**, these visually striking textiles were produced throughout the Navajo Reservation from 1880 to 1895. Serrated zig-zag shapes outlined with contrasting colors give these weavings distinctive optical effects.

The arrival of the railroad to the Navajo Reservation in 1880 with Germantown Yarn and aniline dyes made the creation of the **Eye-Dazzler** possible. Germantown Yarn, a high quality, three or four ply aniline dyed yarn from Germantown, Pennsylvania along with the easy-to-use aniline dyes brightened the weaver's palette and multiplied her color options. The expensive Germantown wool was usually saved for the finest weavers. Without the necessity to shear, card, spin, and dye the wool, women had more time to experiment with new designs and color combinations. Even the average weaver had the time-saving benefit of pre-dyed yarns and many color choices for her own wool.



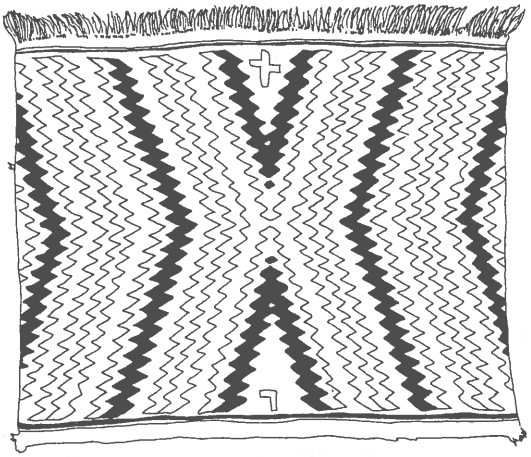
Eye-Dazzler double saddle blanket or small rug, plain tapestry weave (ca. 1890) 46"x 32.5," commercial cotton warp, Germantown weft in white, black, crimson, 2 shades of green, deep maroon, purple, old gold, pale gold, light brown, tan, blue-purple.



Vertical Loom. (Illustration from *Navajo Weaving, Three Centuries of Change*, 1985, by Kate Peck Kent, used with permission of the School of American Research Press.)

Traders discouraged their production after 1900 until the tastes of the psychedelic 1970's made their collecting more popular. The two specimens featured here were acquired by the noted Springfield collector, Thomas C. Condell soon after their manufacture in 1890. These represent a small sample of the Illinois State Museum's diverse Navajo weaving collection.

More information on Navajo Weaving can be found in The **Living Museum Leaflet #11.** For a free copy write The Living Museum Leaflets, Illinois State Museum, Spring and Edwards Sts., Springfield, IL 62706.



Eye-Dazzler saddle throw, plain tapestry weave (ca. 1890) 26" x 31.5," handspun, undyed native wool warp: Germantown weft in scarlet, green, purple, and white.

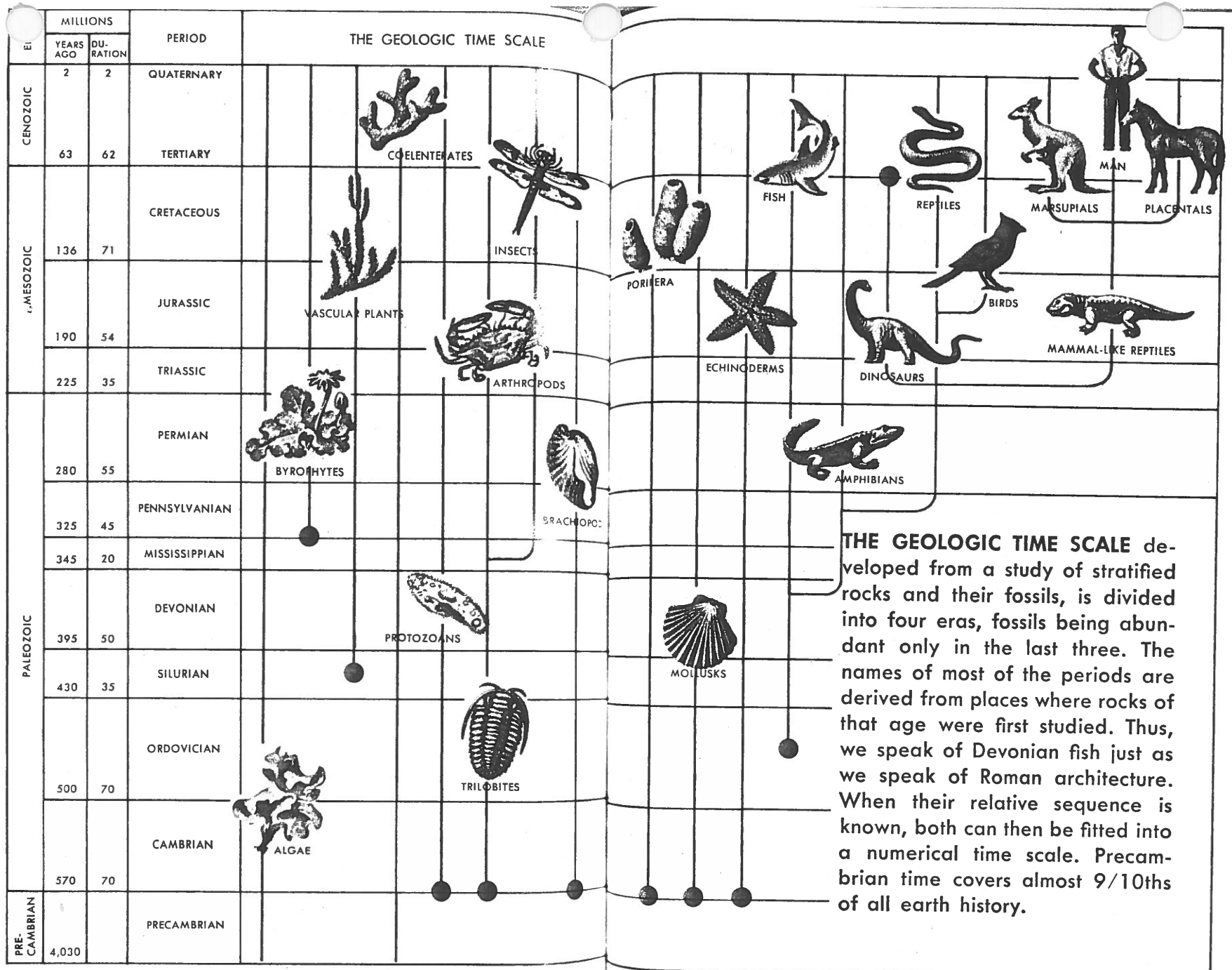
White Ibis by James Lockhart, 1991

THE LIVING MUSEUM
Illinois State Museum
Springfield, Illinois 62706

Non-Profit Org.
U.S. Postage
PAID
Permit No. 878
Springfield, IL

Return Postage Guaranteed

LUTHERAN OUTDOORS MINISTRIES 52L695
PO BOX 239 #16371
OREGON IL 61061



THE GEOLOGIC TIME SCALE developed from a study of stratified rocks and their fossils, is divided into four eras, fossils being abundant only in the last three. The names of most of the periods are derived from places where rocks of that age were first studied. Thus, we speak of Devonian fish just as we speak of Roman architecture. When their relative sequence is known, both can then be fitted into a numerical time scale. Precambrian time covers almost 9/10ths of all earth history.

280 MILLION YEARS

230 MILLION YEARS

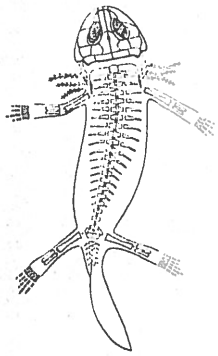
180 MILLION YEARS

135 MILLION YEARS

PALEOZOIC

PERMIAN

Widespread climatic changes led to the extinction of many plants and animals. A generally drying and cooler climate caused many tropical, coal-forming plants of the previous period to die out. Vertebrates made rapid and significant advances: in the seas fishes increased in variety and numbers while amphibians flourished in and near the rivers. Reptiles dominated the land and



EARLY AMPHIBIAN

reached an extreme degree of specialization. One group of reptiles, the pelycosaurs, which include the outlandish sail-backs Dimetrodon *and* Edaphosaurus, *are remote ancestors of present-day mammals.*

MESOZOIC

TRIASSIC

Reptiles achieved great diversity, lending their name to the entire era, the Age of Reptiles. Some of them became fully marine; two of the best known were the ichthyosaurs, which came to resemble sharks, and the plesiosaurs, which have been described as a snake threaded through a turtle. The most common of all Triassic reptiles was the phytosaur, a semiaquatic animal resembling a crocodile. By the end of the Triassic, early crocodiles began replacing the phytosaurs and small dinosaurs appeared. Though subordinate to the vertebrates, the invertebrate world also continued to expand. The seas were filled with reef corals, mollusks, and crinoids. Of the flora, cycads resembling modern palms were numerous and conifers (cone-bearing trees) were very abundant. In fact, trunks of some of these ancient conifers are now preserved and form the Petrified Forest. But the most significant event was the appearance of the first warm-blooded mammals, which ranged from rat size to the size of a small dog.

JURASSIC

In various shapes and sizes, reptiles inhabited the land, sea, and air. While ichthyosaurs and plesiosaurs expanded in the sea, flying reptiles, called pterosaurs, glided through the air. Dinosaurs

EARLIEST KNOWN BIRD

reached their peak and dominated the land. Both carnivorous and herbivorous, they grew to be the largest land animals the world has ever known. Some of the plant eaters were 85 feet long and weighed as much as 40 tons. Still another turning point was marked by the appearance of the first primitive birds, which were comparable to a raven in size.

135 MILLION YEARS

63 MILLION YEARS

0.5 TO 2 MILLION YEARS

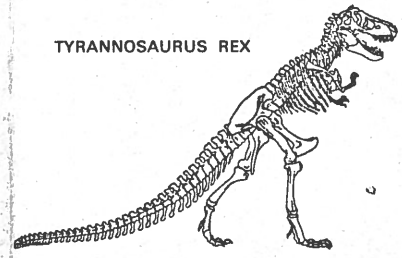
THE PRESENT

CENOZOIC

CRETACEOUS

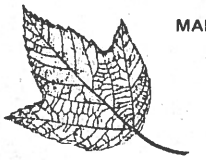
Among the highly significant events of the period was the appearance of the first flowering plants, including modern trees. Among the developing vertebrates, reptiles continued to dominate, increasing in abundance and variety. Dinosaurs became highly specialized. Most famous was Tyrannosaurus rex, *a bipedal, flesh-eating monster over 40 feet long and standing about 20 feet high. But by the close of the period, for reasons still unknown, the dinosaurs were all extinct. One flying reptile attained a 26-foot wingspread. Birds became increasingly specialized—some forms lost their power of flight, becoming suited to swimming and diving, while others had well-developed wings and behaved like modern sea gulls. Mammals were still small, primitive, and inconspicuous.*

TYRANNOSAURUS REX



TERTIARY

The Cenozoic opened with mammals replacing reptiles as the dominant form of animal life. From the simple shrewlike types of the Cretaceous sprang the forerunners of several of our



MAPLE LEAF

modern animals: horses, rhinoceros, elephants, zebras, and rodents—all of which appeared early in the period. Eohippus, so-called "dawn horse," stood 12 inches high; and the earliest elephants were trunkless and tuskless. Many mammals evolved only to become extinct soon after. Among them were the uintatheres, clumsy, small-brained, and elephant-sized, which had horns on their snouts and foreheads possibly for protection against their predators. Amphibians and reptiles decreased. Birds were modern in appearance. The flora was strikingly similar to today and hardwood forests and grasslands spread over the landscape.

QUATERNARY

Vast climatic fluctuations and the advance of the ice sheets marked the opening of the period and greatly affected the living world. Most tertiary animals became extinct while cold-adapted forms, such as the woolly mammoth, evolved. The advancing and retreating ice front caused vast migrations of plants and animals and altered their distribution over the world. With the end of the ice age, many animals such as the saber-toothed tiger, mastodon, and giant beaver became extinct for reasons still undetermined.

SABER-TOOTHED TIGER

Near the end of the Pleistocene, a new primate, Australopithecus, the earliest known species of modern man, made his appearance.