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To All Members Of The Texas Academy of Science

With this issue of the new **Texas Journal of Science** the old **Proceedings and Transactions** of the Texas Academy of Science is no more. Your Executive Council and Publications Committee have been aware for a long time that one of the most pressing needs of the Academy was prompt publication of the papers presented, as well as a more frequent means of communicating with the members and sustaining their interest in the Academy. With this in view it was decided to go from the old **Proceedings and Transactions**, which appeared irregularly, to the present Journal which will be published quarterly and which will be open, not only to members of The Texas Academy of Science but to any scientist whose paper meets with the approval of the Publications Committee, the publication of which will not interfere with, nor exclude, papers prepared by Academy members.

To do this will require a great deal better cooperation from members of the Academy than has been apparent in the past. Papers must reach the editor in such form that they can go to the printer and, because of the exigencies attendant upon the publishing of a quarterly, it will not be possible for the editorial board to enter into extended correspondence nor to coax the person who has presented the paper for a copy of the manuscript and abstract.

To facilitate the work, the following rules must be adhered to:—

1. Manuscripts should be submitted to The Editor, Texas Journal of Science, Box 867, Rockport, Texas. Manuscripts may be subject to minor editorial alterations in order to conform to the general style of the Journal. All manuscripts must be typewritten and double spaced with wide margins. The fact that a footnote is usually printed in small type, closely spaced, does not make it any less likely to need correction than any other portion of the manuscript, and the practice of some authors to single space such interpolations makes it exceedingly difficult to make the necessary editorial corrections.

2. Each manuscript must be accompanied by two copies of an abstract, not more than two hundred and fifty words in length. If the editorial board finds it advisable, the abstract may be published instead of the paper. If the paper can be much improved or condensed the editor may return it for such changes.

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4. References or bibliographies should be arranged alphabetically at the end of the article, without numerical designation. References in the text should be by author's name and date of publication.

The use of footnotes should be avoided wherever possible. These are troublesome to the editor, and a nuisance to the printer, as they have to be properly spaced in the composing, which takes increased time and raises costs.

5. A typical bibliographical entry should be as follows:—

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7. Tables should be limited to necessary comparisons and, if possible, should be clearly typed or hand lettered ready for photography. Printing tables is very expensive.

8. Arrangements are being made with the publisher to furnish three sets of proofs to the editor so that one may be sent to the author for proof reading before publication. However, until we are able to get a sufficient mass of type set ahead, it will be very necessary to return this corrected proof and manuscript promptly or the paper will have to be omitted from that issue of the quarterly and another substituted on which the author has been more prompt. Moreover, remember that extensive changes in the subject matter of the paper after the type has been set are expensive, and time consuming. If such changes must be made the expense will, of necessity, fall on the author.

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the fact that in the past it has been the custom for the editor to obtain the reprints from the publisher and then collect from the individual member.

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NOTE

Your Editorial Board is anxious to make the Texas Journal of Science the very best publication that it possibly can. For that reason we welcome criticism of this first number, especially. Already we have seen at least two places where changes will improve the format of the Journal. Doubtless the members of the Academy will see others. If you do please drop the editor a line.

We would like to state, in passing, that it is not going to be possible, for mechanical reasons, to use ordinary type, black face and italics, without greatly raising the cost. For that reason we have, in this first issue, used only regular and black face.

J. L. Baughman, Editor
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Texas Journal of Science

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POCKET GOPHERS AS ARCHITECTS OF MIMA (PIMPLE) MOUNDS OF THE WESTERN UNITED STATES

W. ARMSTRONG PRICE
Consulting Geologist
Corpus Christi, Texas

ABSTRACT

Small structureless bi-convex mounds of fine to coarse, sandy to gravelly soil, 1.5 to 8 feet high and 10 to 200 feet wide, are found in large colonies with sub-equal distribution and unimportant variations as mima, "pimple", "sand", or "hog-wallow" mounds in sandy soil occurring widely in most major geomorphic provinces west of Mississippi river. "Hog-wallow" mounds in heavy clay and polygonal earth mounds of frozen ground—locally more numerous and closely spaced—are excluded. Mima mounds are built and occupied by small fossorial vegetational rodents in grassland or forest glade, but only under marginal living conditions of impaired underdrainage, or too-thin soils. No physical agency can form mounds so widely distributed. If it could west, why not east of the Mississippi? Seen to form in from 5 to 17 years, the mounds persist for thousands of years on stabilized plains. They diversify soils, drainage, groundwater, vegetation and distributions of soil-living animals. This study combines the latest field work of mammalogists, soil scientists and ecologists studying the rodent and mounds, with a full review of the literature and a continent-wide analyis of mound distribution. Some 40 living scientists have contributed unpublished data.

INTRODUCTION

These small round to oval, tabular, domal, to conical mounds of sandy or gravelly soil, 1.5 to 8 feet high and 10 to 200 feet wide, occur in colonies of hundreds of thousands on treeless prairies, in woods and some forests, in mountain meadows and on other surfaces of slight topographic relief from the coast of the Gulf of Mexico in Louisiana and Texas through the Rockies to Washington and Oregon, Fig. 1.

These mounds have for 100 years excited the curiority of scientists, especially as, until the present decade, no satisfactory explanation of their presence had been found in spite of numberless suggestions and partly developed hypotheses put forward by naturalists and professional scientists of numerous branches. The failure of these hypotheses and the mystery of the mounds seem to give us another example of the difficulty of solving a problem that intrudes itself into several departments of science during their early stages, while its solution requires a broad synthesis in several of these, possible only at somewhat advanced stages. In this case ecology is the meeting ground.

The pocket gopher * is an underground rodent farmer, living in porous, sandy or gravelly soils and eating roots, bulbs and some above-ground parts of plants. Two students of this farm and garden pest, W. W. Dalquest and V. B. Scheffer, as late as 1942, as a result of detailed field investigations of the habits and living conditions of the gopher, finally gave us a clew to mima mound building which has proven highly fruitful and has permitted, for the first time, a relatively thorough analysis of the origin, occurrence and scientific significance of these mounds to be made.

* The pocket gopher is a small, shy, chunky, rat-sized or squirrel-sized rodent with a variety of fur coloration. The more active, slenderer, whistling, ground squirrel and a land turtle have been called "gophers", the word connoting "diggers".

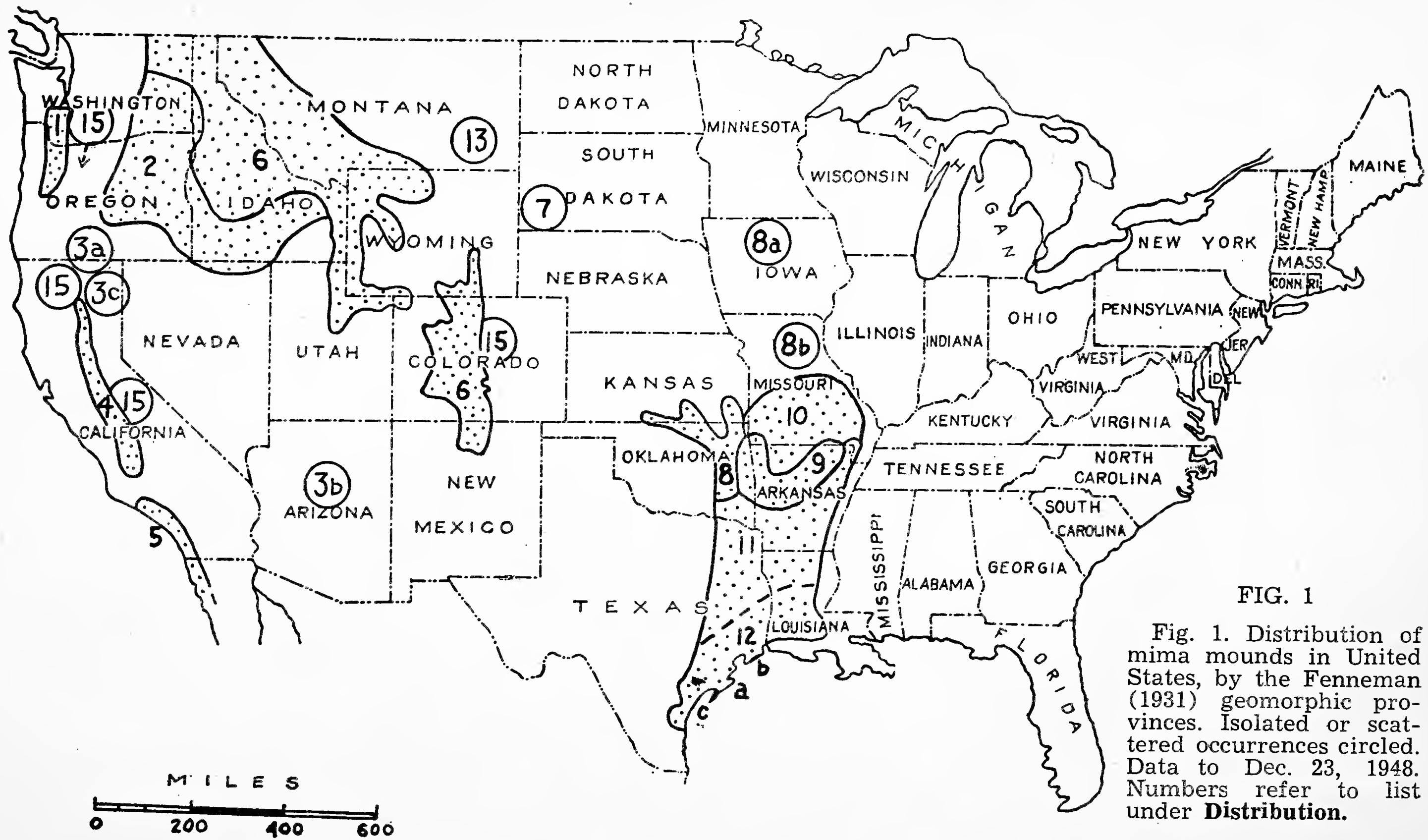


FIG. 1

Fig. 1. Distribution of mima mounds in United States, by the Fenneman (1931) geomorphic provinces. Isolated or scattered occurrences circled. Data to Dec. 23, 1948. Numbers refer to list under **Distribution.**

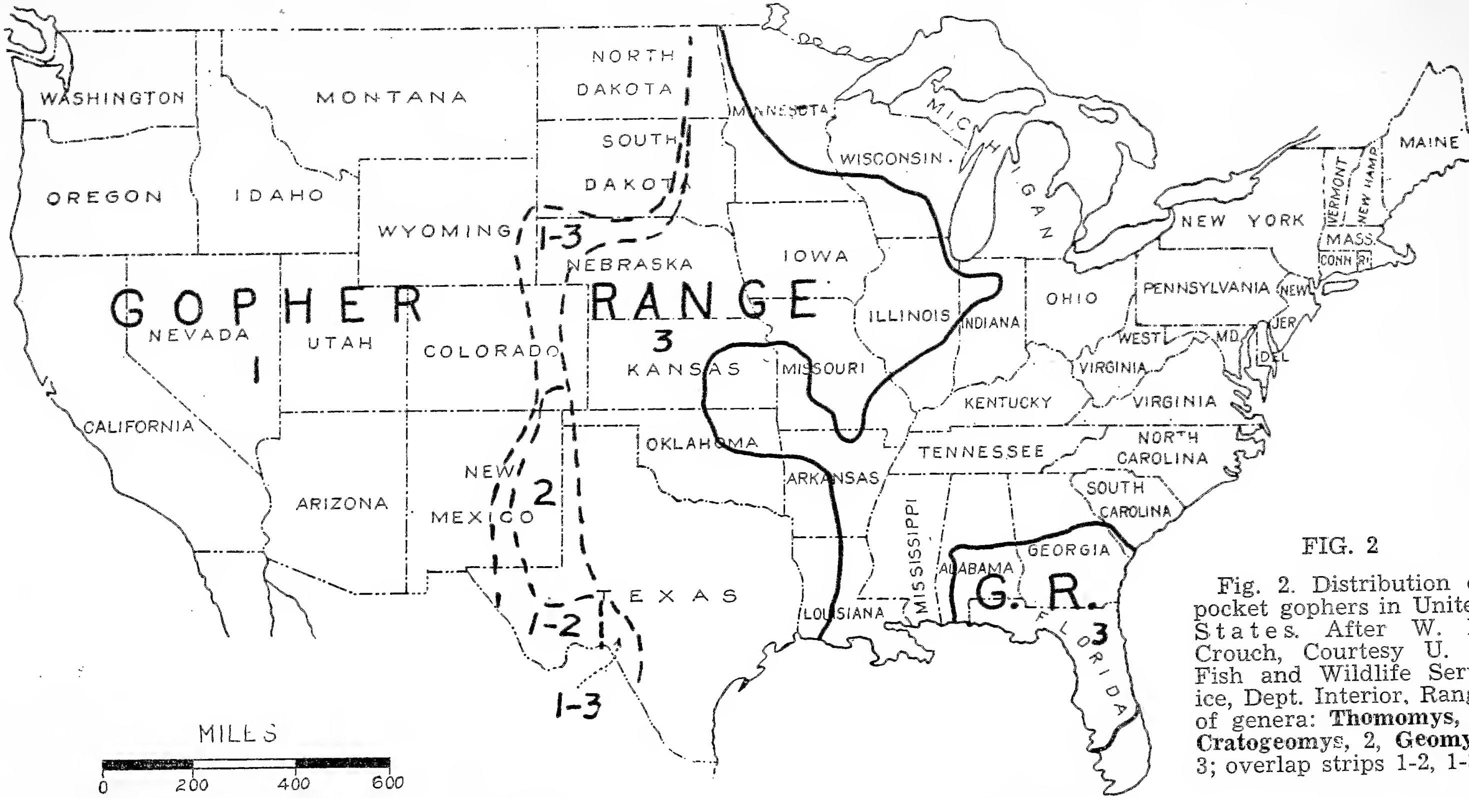


FIG. 2

Fig. 2. Distribution of pocket gophers in United States. After W. E. Crouch, Courtesy U. S. Fish and Wildlife Service, Dept. Interior, Range of genera: **Thomomys**, 1, **Cratogeomys**, 2, **Geomys**, 3; overlap strips 1-2, 1-3.

The subject of mima mound origin was reopened by a symposium in the pages of the Scientific Monthly from October, 1947, to April, 1948. This began with a restatement by Scheffer (1947) * of the work and conclusions of Dalquest and himself and included the happy discovery and publication of a long-lost first-hand observational study of the actual construction of mounds where the rodent was the only active soil-moving agent (F. C. Koons 1948). The symposium discussion continued until the writer's review and analysis was well under way, when the editors of Scientific Monthly kindly referred further contributions to him. The writer's study has been made possible largely through the assistance of leading students of the pocket gopher and his environment, working mostly in the Federal scientific bureaus, who have placed the current results of their investigations at his disposal. Most of the results of late ecological field studies were learned through the interest of V. B. Scheffer, William B. Davis and the Scientific Monthly. Material not available to the symposium writers and a wider distribution study have contributed to the present results.

Some forty scientists have contributed information to the current study, the larger number supplying data on regional mound distribution. Ecologists, mammalogists, soil scientists, geologists, anthropologists, and others have cooperated freely. The pertinent literature has been reviewed by the writer in the attempt to compile and collate all vital information on the subject available at the end of 1948. New geological field work has been done on mounds in Texas, Louisiana, Oklahoma, Arkansas and Missouri. Observations of pertinent soil and topographic features have been made in seven states not known to have mima mounds.

Individual acknowledgment can be made here to only a few of those who have so generously assisted, and the writer assumes full responsibility for the conclusions and this summary. Full publication is planned elsewhere.

Mound Correlation.—Detailed field analysis, some topographic mapping and the aerial photographic coverage of the continental United States now available, make it possible to correlate these mounds in different regions—the mima mounds of the Pacific Northwest, the sandy "hogwallow" mounds of California, and the "pimple" ("gas" or "soil") mounds of the Gulf Coastal plain and continental interior—into a form genus **mima mound**, eliminating "hogwallow" mounds in clay and the deep-seated polygonal-earth structures of frozen ground.

Distribution.—Thus constituted, and as further described herein, mima mounds are found to occur in 18 Western gopher-occupied states, Fig. 1, and wholly within the distribution regions, Fig. 2, of the pocket gophers, genera: **Cratogeomys, Geomys** and **Thomomys,** ** but only in areas marginal for these underground rodent farmers. This restriction leaves mima mounds unreported in 10 gopher-occupied states: 4 west of Mississippi River, 3 Central, and 3 Southern states, all occupied here and there by gophers living under optimum conditions. Mounds are absent also in 20 Eastern states, where gophers are not present, giving

* This well illustrated article should be consulted in order to gain a good idea of the appearance of the mounds.

** Sub-family Geominae of the Family Geomidae.

30 states without mima mounds. Scanty information shows gophers, but no mima mounds, present in southern Alberta and Saskatchewan. Mounds, thus, occur in 18 out of 30 western states of the United States and Canada that are occupied by gophers.

Mounds are reported on a coastal terrace—uplifted shoreline—in Baja California, Mexico. Reports of somewhat similar mounds in Argentina, Australia and Cuba have not been investigated by this writer. R. T. Hill's (1906) reference many years ago to mounds on the High Plateau of Mexico has not been confirmed and the mounds noted by him may have been of other type.

The larger number of the known mima mound colonies is found in soil on little-consolidated deposits of Pleistocene age. A lesser number is found in soil on Recent deposits. Many, however, lie in soil developed on older rocks, including Paleozoics, where they and the soils are associated with erosional surfaces of Pleistocene to Recent age, now inactive or in old age of the erosion cycle.

Mima mounds are widely reported from nearly all those major non-desertic geomorphic units (Fenneman 1931) of the West that are of relatively smooth topography, and from meadows and glades in some mountains. These, shown on Fig. 1, are: **1,** Puget Sound Basin; **2,** Columbia Plateaus; **4,** Central Valley or Trough of California; **5,** Pacific Border terraces; **6,** Rocky Mountains; **8,** a. b, Central Lowland areas; **9,** Ozark-Ouachita Region; **10,** Ozark Plateaus; **11** and **12,** Gulf Coastal Plain; **15,** Various mountains; **3,** a, b, c, scattered locations in Basin-and-Range province. On river terraces they occur, **13,** below the surface of the Great Plains, (and probably, **7**). The deep watertables and porous surface soils of the Great Plains itself, however, seem not to have required the gophers to build mounds, although these rodents are numerous in parts of the region. Mounds have been reliably reported or seen by the writer on more than 20 different types of geomorphic units, as: terraces of sea and river, entrenched alluvial fans, till surfaces, stabilized deltaic plains, beach plains, elevated or drained parts of lake basins, plateaus and mesa tops, slowly eroding hill slopes, level to steep mountain "meadows" (various units) and baselevelled surfaces in old mountain areas.

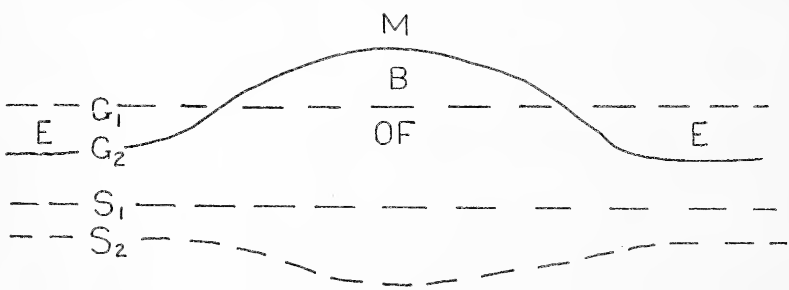
Mounds are absent in the United States from areas of unleached heavy clay soils, as floodplains of lowland rivers. Mounds of loose sandy soil occur near Stockton, California, where the soil of the surrounding plain is a lightly cemented, more clayey adobe. In forested areas, mounds seem to have been built only in open glades, but occur where a forest climax growth has developed on them, displacing the gophers.

Young mima mounds are reported on slopes up to 15°, 20° or even 30° on mountain meadows, but are most common and in general older on slopes of slight inclination, as 1 to 5 feet per mile in Texas and Louisiana. They occur in all climates from humid to semi-arid, but seem to be least abundant in the latter. Mounds have not been reported from deserts, probably due to instability of the soil, although pocket gopher species occur in some fully arid regions. Mounds are absent east of Mississippi River, including a part of the Middle West, where gophers occur. Mounds are absent also in the great Eastern Forest Region, although gophers occur in open areas there in the eastern Gulf of Mexico states, Fig. 2.

Mima mounds are today typically occupied by pocket gophers, one to a mound in non-breeding seasons. Yet Mima Prairie, type mound locality, is not now occupied (Dalquest and Scheffer 1942), being one of several areas of abandoned mound prairies. When too severe living conditions arrive, gophers are known to abandon mounds, as when the Texas harvester ant, **Atta texana,** takes up residence or when the mounds are entirely flooded by fresh or salt water, as at Locality area 12 b, Fig. 1, (**contra** R. L. Dietz 1945). If a mound prairie were drained, and the watertable fell, the intermound soils would in many cases have become too dense for gopher cultivation. Some mound colonies now have no gophers, but no large regions containing mima mounds seem to be known without gopher occupation of most of their mound prairies. Other occupants, as ground squirrels, badgers, skunks, and ants, are thought to be post-mound invaders, none of these except perhaps the ant having a known soil-gathering habit.

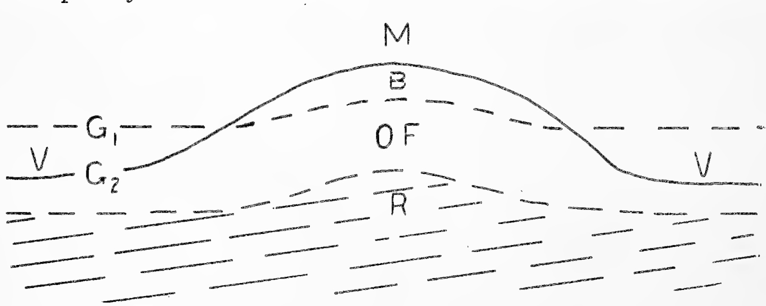
FIG. 3, A, B.

Fig. 3. Hypothetical Cross-Sections of Mima Mounds in Relation to Original Ground Surface and Soil.



3A. (above) Sandy Soil Originalfly with Smooth Surface. G1, original ground surface. G2, surface after mature mima mound (M) is built. B, volume added; EE, volume extracted. OF, original gopher-farm area, soil now thoroughly reworked and original structures destroyed. S1, original base of soil, S2, present base of soil, assuming weathering has proceeded in depth, aided by deep tunnelling under mound.

3B. (below) Sandy Soil with Rill Sculpture. M, gopher enlarging rill divide by extraction from rill valleys, VV. R, possible core of unweathered gopher-resistant rock retaining original pre-soil structures, or incompletely reworked rill divide in new mounds. B and OF as in 3A.



The building of mima mounds diversifies the environment as to topography, soils (C. C. Nikiforoff 1941), drainage, soil moisture, groundwater, vegetation, and indigenous and transient animal populations.

Mound Structure.—Mima mounds form unnatural, usually biconvex thickenings of the upper, surface soil zone, Fig. 3A. This is believed, as M. R. Campbell (1906) pointed out long ago, to indicate mound origin by accumulation rather than by erosion or other removal of the soil.

Mounds are typically structureless, except for (1) tunnels, nests and dens of animals, and in some areas (2) thin basal (in some cases post-mound) soil claypan and hardpan layers, (3) basal and peripheral concentrations of gravel or cobble, (4) possibly in a few cases, internal pre-mound and sub-mound structures (R. J. Arkley 1948), Fig. 3B, not yet surely identified in the field. Such hypothetical pre-mound remnants, as long as preserved from destruction by tunnelling, would be partly or wholly covered unconformably by gopher-transported soil materials and, if gopher-resistant, could long retain original internal composition and structure. The only stratification, flow lines or cross-bedding to be found—if at all—in mima mounds should be in such bodies.

Fossils have not been reported from mima mounds, but may possibly be found in internal pre-mound structures, until destroyed with these by soil and rodent activity. Indian burials and artifacts have been reported in California from a few mounds in mound colonies once forested and abandoned by gophers. Boulders too large for gophers to eject, reported "high on mounds", may have been as yet not covered in mound building, elevated by frost heaving, or exposed in abandoned, eroded mounds. This feature requires further field investigation.

Sub-mound soil hardpans may have large sub-central underground dimples or openings which allow groundwater to rise into the mound above during very wet seasons, temporarily producing a central area of quicksand (C. C. Nikiforoff 1941), but mima mounds do not show the deep pipe-like structures which some have expected, based on assumption of mound formation by upward seepage of water. Nor do they show any evidence of extrusive action while growing, nor extrusive, nor flow, structure. The hardpan dimples, collapsed nest chambers, and dens of larger animals explain sub-central surface depressions found on many mounds. Peripheral depressions of inter-mound surfaces are common at the margins of growing mounds and must be due to horizontal underground transfer of material to the mound (Koons 1948) by the animal.

Patterns of Occurrence of Mounds in Colonies.—In mound colonies, mounds are often roughly equally spaced but by no means precisely so —in many places very irregularly spaced in some directions. They occur in more regular patterns of arrangement only where they are built on pre-existing small elevations having, themselves, some regular pattern. Most common in this class are rill divides, beach ridges, or low stabilized dune ridges. The sub-equal regularity of spacing of mounds and their sizes, are reported (Dalquest and Scheffer 1942; V. B. Scheffer 1947, 1948) as closely similar to the sizes and patterns of occurrence of individual gopher-farm areas where mounds are not present.

Circularity of Mound and Gopher Farm.—Although gopher tunnel-systems commonly have a marked degree of rectilinearity at any one time, Scheffer (1948) believes that, over a long period, the tunnel layout will shift so that, on a long term basis, the rodent will farm mainly a roughly circular area. This seems to be most marked in areas of marginal occupation conditions. There are indications that, where mounds are well developed, feeding and tunneling activity occurs throughout the mound in a season. Thus, individual mima mounds observed near Aransas Pass, Texas, showed gopher activity in all parts of a large circular mound during some period of not many weeks preceding Feb. 1948. The area of activity was marked by the many rain-eroded, hat-sized "hills" of sand piled over the ends of tunnels, Fig. 4.

Fig. 4. Young mina mound occupied by pocket gophers.

Portion of mound (2 by 100 by 100 feet) on late Recent marshy plain of cove between spits, Aransas Bay shore, at townsite of Aransas Pass, Aransas County, Texas. More than 500 hat-sized gopher "hills" eroded by winter rains with a few fresh ones. Photo, February 1948, by Price.

In the two eye-witness accounts of mounds built in 5 to 17 years (Koons 1948, T. L. Bailey 1923) in one of which the gopher was observed to be active throughout the period, the mounds were reported as typical for their areas, which would mean oval to roughly circular in shape.

Gopher Activity Without Mound Building.—Optimum soil and terrain conditions for pocket gopher "farming" seem to be deep, porous, sandy (W. B. Davis et al., 1938) **to gravelly soil with good surface and underground drainage.** Here, plant roots penetrate deeply and the gopher is limited in its solitary farming only by the radius of its customary horizontal travel, which is that of mima mound radii, with only occasionally, longer, reconnaissance journeys underground and a minimum of surface foraging. **Mima mounds are not built where the gopher lives under optimum conditions. In much the larger part of its range, mima mounds are not built.**

Some Conditions of Mima Mound Building.—Where mima mounds are present, living conditions for the rodent are marginal, although improved by mound building. Here, before mounds were formed, the roots of grasses and forbs ('weeds") were prevented from growing deeply and so **occupying a maximum underground volume of earth beneath a surface area.** Here, the "farm" was shallow and spread out instead of deep. Shallow root penertation in gopher-occupied regions is chiefly the result of thinness of porous soil above clay, rock or shallow ground-water. The North American gopher seems not to tunnel in dense clay, although an Australian relative is reported to build mounds of clay, suggesting a difference in food plants for the different genera.

The minimum vertical thickness permitting the gopher to tunnel, obtain roots, and remain hidden from surface enemies is a few inches more than the diameter of his small, chunky body—or as little as about 5 or 6 inches. Although controlled field investigation has been confined in this item chiefly to a single gopher species, rise of the watertable to as close as 4.0 to 4.5 feet below surface leads this species to build mounds. **Where the thickness of soil is less than some small limiting value, it would seem that too great a horizontal radius of foraging would be required for the rodent to secure adequate food without mound building.**

If the minimum volume of soil is in considerable part occupied by dense bodies, small enough for the gopher to push along a tunnel, such as gravel and small cobble stones, they will be pushed up and out of the mound with the head and forelegs. If larger, they will be undermined and allowed to settle to its base. Thus, **the mound is cleared of obstructions to tunneling.**

An impenetrable barren surface layer such as a tightly packed gravel pavement (as an eolian pavement, residual from the winnowing of fines from gravelly soil) covering a suitable soil also prevents the occurrence of optimum living conditions for the gopher, as at Rocky Flat, Yakima County, Washington, (E. J. Larrison 1942), by severely limiting plant growth. **Here mounds have been built by transfer of material from below the pavement through some original central break, the pavement being observed to sag beneath the mounds.**

On level-topped rocky mesas in California where the soil is only a few inches thick, mima mounds have been observed with gopher occupation. The mounds are—in some cases at least—more widely spaced than where soils are thicker. **This type of occurrence,** reported by Herrick C. Brown, **indicates that the gopher transfers soil horizontally from as far away as necessary to build a mound.**

Where such limiting conditions occur, the environment is marginal for the rodent. **Where suitable soils are found in the West in such gopher-marginal conditions, and other conditions are not unfavorable to gopher habitation and propagation, mima mounds are commonly**

found, but only on surfaces where the soil is and has for a long time been stable, that is, protected from excessive erosion or deposition. Studies of such conditions do not yet permit a statement as to how much suitable terrain remains **in the West** unoccupied by gopher colonies or mima mounds.

Relatives of the rodent, such as the beaver and musk rat, have highly developed, above-water, house-building habits suiting them to life in conflict with water, the living quarters, however, being above water and dry. The beaver is well adapted to living partly in water, being a good swimmer.

Rodents in general construct nests, some of which, though not of soil, are distinctly mound-like, as that of the pack rat of the Southwest. The pocket gopher, however, while customarily building a small, food-supplied nest chamber in the earth near the center of his farm area, does not show a mound-building ability until natural dispersion of the young from the home nest, or other migration, brings individuals up against marginal conditions. **Enough is now known to state that the pocket gopher develops a positive mound-building activity when faced with certain types of marginal living conditions.**

A mature mima mound has been built in 5 years and mound building probably continues through more than a single gopher generation. Hence, gophers live under some marginal conditions while improving them.

Mechanism of Mound Building.—In searching for clues to the precise mechanism of mima mound building by the gopher, the following considerations enter strongly. The animal customarily shifts earth in his tunneling by pushing with the forelegs and head. Upward transfer of soil in large amount is shown by the sagging of the gravel pavement on which extensive mound colonies are built at Rocky Flat, Washington. Lateral soil transfer in bulk from intermound to mound areas is inferred from (1) the aggregation into mounds of a thin soil from wide intermound areas on rocky mesa tops in California, (2) the characteristic occurrence of marginal sinks widely observed at the edges of mounds of the Gulf Coast in Texas by Koons, the writer and others, (3) from the abnormal thickening of the soil layer in mounds, (4) from their being built abundantly on surfaces of such gentle slope and poor drainage that erosion can not have been effective in shaping them.

Visible records of the gophers shifting earth in variable quantities are: (1) the ubiquitous "hills" or hat-sized piles of soil left on the surface over the ends of tunnels of lateral as well as vertical courses; (2) back-fillings and plugs of soil constructed in tunnels, including (a) the tunnel-end-plug located beneath each "hill", (b) "ropes" of soil found abundantly on ground surfaces where a snow cover has lately melted, representing back-fillings of tunnels in snow, (3) **and the second-story, seasonal nest and food-storage mounds,** (P. F. English 1932, pl. 9, widely observed in the Gulf Coast and in Utah. These are, in Texas, 3 by 4 feet in plan by 2.5 feet high. They are found in many regions in central locations on mima mounds in wet seasons of high watertables and are rebuilt seasonally. Rain, wind and the hooves of heavy animals reduce them. Predators doubtless dig into them.

The Wet-Season Nest-and-Storage Mound.—So far, the full range of conditions controlling the building of the wet-season nest mound is not known. It has not yet been reported from some extensive areas of gopher and mima mound occurrence, V. B. Scheffer not having seen them in the Pacific northwest.

The normal nest chamber, with its food cache, is reported as characteristically central in position and either shallow or deep. The wet-season mound is built on the ground surface vertically above the dry season nest-chamber.

Attainment of Maximum Mound Heights.—The tabular mima mound is in Texas usually no higher than the wet-season nest mound. In the absence of observational records, the higher conical or domal mima mound is thought to develop from the low tabular mima mound because of the characteristic rise of the watertable under surface elevations, especially in rainy seasons. Thus, the watertable does not pass level under a hill of porous materials, nor does it lie at equal depths below the surface of the hill at all points, but its curve tends to be flatter than that of the hill surface. Then, the rainy-season watertable would seem to rise centrally with the up-building of a mound and would tend to cause a continuance of mound building until there was a sufficient volume of plant-developing soil above high watertables to provide a crop large enough—with existing food hoards—to carry the rodent through the wet season. This phase should be fully investigated in the field. Local groundwater elevation in mounds is reported from the Stockton area, California, by J. L. Retzer (1946).

It has long been observed that there seems to be a maximum height for mima mounds on any one mound prairie. While height control is not yet fully understood, this height may vary with the size of the species and with the age of the mound-building activity in the area, and be limited by the sub-mound rise of the watertable after rains.

The maximum height and volume limits may be influenced to some extent by the volume of soil through which the energies of the rodent carry him, and by a balance between mound-building activity and the activity of external mound-destructive forces. **If after a mound reaches a certain height, the rodent no longer needs to enlarge the volume of the "farm", growth will probably cease.**

The maximum in observed mound building is the Rocky Flat, Washington, area, where extensive mound coalescence and probably overlapping seems necessary to Larrison (1942) to account for the extensive covering of the gravelly pavement to form a terrace of soil over wide areas. Similar terrace building without a well defined reference bed is suggested by the topography of some hummocky bog or swamp terrain, such as is reported from California (J. L. Retzer letter of Oct. 1948) and as has been observed in Kleberg County in a few areas on the abandoned, poorly drained flat of the Ingleside Pleistocene lagoon floor. The lagoon floor is there covered by a thin veneer of wind-blown sand in the present dry sub-humid region along Baffin Bay, Texas.

Colonial Soil Mounds and Their Origins.—The sub-equidistant occurrence on extensive grassland prairies of colonies of small, low, roughly symmetrical mounds of soil unaccompanied by other, irregular and larger soil elevations would, it seems, be capable of association with, and possibly only with: (1) habitation areas or structures of animal colonies of a single type, (2) dunes of sand-sized particles, or (3) relief features resulting from volume changes (swelling and contracting) in relatively homogeneous bodies of soft, adhesive (coherent) surface or near-surface materials, such as heavy clays. The structures of the United States known to fall within these specifications are: **A. Mima mounds, B. Dunes, C. Hogwallow mounds in heavy clay soils, D. Polygonal earth mounds** of soils underlain by seasonally partly melted ground-ice masses. Other well known small-mound * groups fail in some items of the definition.

Mima mounds are not features of heavy clay soils in the United States, and are in many regions characteristically larger and much less regularly distributed and less thickly set than hogwallows in clay. Dunes and mima mounds lack the deep-seated, inverted pyramidal structure of polygonal earth mounds, lately invoked by Péwé (1948). Mima mounds are not found in active growth above ground-ice. Gophers do not range into the areas of permanent ground ice.

Similarity of shapes, sizes and patterns of distribution as observed on aerial photographs, and the characteristic structureless, bi-convex form of the soil body of the mounds, indicate that the mound colonies here mapped (Fig. 1) are all of mima type.

Hypotheses of Mound Origin.—The vital facts in the occurrence and character of the completed mounds are (1) the absence of mima mounds beyond the range of the pocket gopher, especially their absence east of Mississippi River, (2) the common presence of the gopher in the mounds, (3) the abnormal thickening of the soil in the mounds and its high porosity and permeability as compared with the intermound soils, (4) the absence of internal structure of a geological nature, (5) mound occurrence under such a wide variety of conditions that, if they are of a single type, no single **physical** agency may be involved, (6) their occurrence as local widenings and heightenings of such plains-summit features as rill divides, inactive beach ridges, and stabilized dune ridges, (7) their growth in areas where and while no upward propulsive force exists in the ground, as where regular, periodical observations of water levels under mima mound prairies were made in deep dug wells by Koons (1948 and oral statement).

We have the testimony of two eyewitness observers, F. C. Koons (1948) and the resident of Colorado County, Texas, interviewed by T. L. Bailey (1923), as to the actual growth of mounds in a few years, from an observed small beginning with gopher occupancy in one case, and from newly leveled land in the other.

We have also the report by many observers, the writer included, of the occurrence of a developmental series of mounds where the gopher is the only large soil-disturbing agent; also the evidence of the occurrence of the mounds characteristically where conditions for gopher occupation are, or demonstrably have been, marginal for the rodent. Here, the mounds seem to have been built by the rodent chiefly because

* Prairie dogs and ants build craterlets, not mounds.

the soil was too thin above relatively impenetrable materials, or above groundwater, for the growth of the plants on which the gopher depends and because of an impaired under-drainage for soil waters. **These associations are too specific, too widespread within the range of the pocket gophers, and cover too many different geologic and geomorphic conditions for the mounds to have multiple origins or to be the result of coincidence.** These conditions also rule out beyond any reasonable doubt agency by any other organism, as (a) other rodents having quite different habits, food and living requirements, (b) ants, or (c) human aboriginees. The aboriginees had just as definite camp-site requirements as have the lesser animals.

The writer believes that each agency for mima mound origin previously advanced, except that of the pocket gopher, can be shown to be inadequate on internal evidence. For example, the mounds are not sections of rill divides (F. A. Melton 1929, pp. 126-7, fig. III; 1935) but are elevations on and widenings of them; also they occur numerously where rills can not have formed and without rill patterns; they are not accumulations of atomospheric materials alone, or around or in (J. L. Rich 1934) bunch vegetation, because they lack streamlined form, dune structure, the patterns of dune occurrence, and the size grading of dune particles (Melton 1929). They also occur in humid areas where the typical vegetational growth is not bunchy. Human artifacts and remains rarely occur in the mounds, possibly in part because of gopher activity, and are not characteristically found in adjacent terrain, as they would be if the mounds were of aboriginal origin; ants do occupy mima mounds, one colony to a mound, and ants do raise small amounts of materials to the surface, but can scarcely accumulate soil from radial distances of scores of feet, as do pocket gophers; mima mounds occur where no deposition under water has been possible, as on the upper reaches of Criterion Summit, Pike's Peak, and Table Mountain, even on slopes up to 30°. **No trained observer has as yet offered a critical separation of the mounds here termed mima into sub-types related or supposedly related to origin by different agencies, nor is evidence known to the writer on which such a separation might be made.**

The proponents of the various hypotheses and suggestions opposed to gopher origin have not attempted on any critical grounds to explain the absence of mima mounds east of Mississippi River or otherwise beyond the gopher's range. If such agencies operate in humid climates, they should be able to form mima mounds on the Atlantic coast, including the sandy Tertiary outcrop of the coastal plain, the rolling hills of the piedmont, and the many grassy mountain meadows with porous soils found in the Alleghanies. The pocket gopher and the mima mounds, on the other hand, are both characteristic of the West, not of the East. The few areas occupied by the gopher east of Mississippi River seem to offer optimum conditions, not requiring mounds, as also large areas in the West, such as the High Plains with its deep sandy soils.

Ages of Mima Mounds.—Known and supposed ages of new mima mounds range from the recorded 5 years of Koons (1948) and 17 of T. L. Bailey (1923) for first attainment of mature form, to figures estimated for the attainment of the associated vegetational climax formation, 50 to 60 years, and to the 1,000-2,000 years (C. C. Nikiforoff 1941) estimated as necessary to develop some California intra-mound soil hardpans supposed to be of post-mound age.*

Maximum possible mima mound ages are set by the times of stabilization of the erosional and depositional surfaces on which they are found. These surfaces date from middle to late Pleistocene, and early to late Recent, and are commonly estimated to range from 2,000 to 200,000 years in age.** The profuse varietal development within the **Geominae,** and the many local races restricted by terrain barriers of relatively small size—as clay-soil areas—argue for substantial time intervals for gopher occupancy of the areas of present mound colonies.

Fluctuation of Mound-Building Activities in Recent.—Partly unpublished data indicate that the present semi-arid and dry sub-humid regions of the southwestern United States from the coast of the Gulf of Mexico (W. A. Price 1944) to the Grand Canyon region (J. L. Hack 1942) have undergone a cyclic climatic change from arid to moist to dry, with superimposed pluvial epicycles and corresponding fluctuations of the watertable in the past 8,000 years. The longer moist period is roughly estimated to have extended in Texas from about 2,500 B. C. to about A. D. 600, with a short one from about A. D. 1100 to 1400. Such widespread changes in watertables on lowland plains as accompanied these changes must have affected the gopher colonies so that mound building activities fluctuated markedly during the late Recent, with periods of cessation. Concurrent changes probably also occurred in the adjacent more moist climatic regions of today. Some areas of early mound building may not be marginal today and might not today require mound building. Also, some grassland areas became covered by forests so that gophers disappeared. They may not have returned to all of these. Such events may have caused some of the few exceptional occurrences of mima mound prairies not today occupied by gophers in some of which the original marginal conditions responsible for mound building are now obscure, as at Mima Prairie, itself, the type locality of the mounds.

Present Status of the Mima Mound Problem.—(1) Mammalogists and ecologists may not be fully satisfied with the conclusions and geological interpretations here presented. All doubts as to origin can be settled by placing families of gophers in experimental tracts in various marginal situations, and charting mound building under detailed observation and controlled conditions. Doubtless this will be

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* Some mima mounds near Stockton, California, show Indian occupation and burials. The mounds were once heavily wooded and were presumably then abandoned by gophers. Indian skeletons in the mounds lie under a zone of carbonate concretions at 4 to 12 inches depth. This situation indicates considerable antiquity for the burials and the age of Indian occupation has been roughly estimated by its students at 3,000 to 10,000 years (J. L. Retzer 1946, p. 365). The stage of adobe cementation in the Stockton soil of the plain in contrast with that of the mound suggests to Price that the mounds are as old or almost as old as the soil.

** The writer does not hazard a guess as to actual maximum mima mound ages. Low sandy beach ridges of mid-Beaumont age (Yarmouth interglacial?) have lasted possibly 200,000 years. Mima mounds rest on them, being of the same order of size and resistance.

done if it is judged to serve an economic purpose. Underground gopher movement and tunneling might be followed by the use of delicate listening devices. (2) The chief geological hypotheses of recent decades opposed to animal origin have been those of multiple origins, including rill-divide segmentation, and bunch-vegetation holding soil residuals and accumulating atmospheric fines. These problems can be further investigated (a) by multiple gopher-mound-building experiments in the various parts of the country occupied by the mounds here correlated into the mima type, (b) by searching for and, if found, investigating the patterns of occurrence of hypothetical colonies of round to oval rill-divide segments, especially if found east of Mississippi River, or in Canada, where gophers are scarce or not present, (c) by searching for bunch-grass or brush-held mounds in extensive colonial development in those regions. (3) The ant-agency idea may be difficult to investigate because of the great variety of ants and the probable slowness of growth of their accumulations. The only known present proponent of this idea (P. Viosca 1944) has not developed it in publication but believes * that **Atta texana**, the leaf cutting ant of Texas, is the only type likely to have built mounds of this size. (4) The possible influence of seasonally shallow watertable in causing the growth of mounds above the initial low tabular structures may be studied in the field. (5) The tolerance of different species of gophers for varying shallow positions of the watertable may be further investigated; also (6) the influence of the activities of other rodent occupants of mima mounds on mound size where they alone occupy them. (7) Detailed shallow subsurface investigation of a few localities in East Texas, including mima mound prairies, where the writer and E. T. Dumble (1918, pp. 273, 174) observed tiny craterlets growing by ground-water seepage, with small amounts of petroleum and natural gas, might be made.

Some of the above projects give promise of useful results, others are suggested for the benefit of those who will be reluctant to accept the mound correlations here made or to abandon formerly held hypotheses.

It is thought that the varying conditions found in the soils of mima mounds and the adjacent plain or slope, and differences in the continuity and position beneath the mounds of lower soil horizons may be explained on the basis of the pocket gopher hypothesis, if they are carefully investigated by sectioning or auger boring, and if the concept of the probability of long-continued slow growth of some mounds be weighed against possible short time growth of others, in relation to the progress of soil development. There may also enter into the soil problem possible fluctuations of climate during the life of the mounds as topographic features; also fluctuations of gopher occupation.

CONCLUSIONS

This article is too brief for a full consideration of all the results of the study completed by the writer. The abstract and the boldfaced matter under the headings: "Circularity of mound and gopher farm",

* Personal communication. Ants are said not to move earth horizontally for significant distances.

"Gopher activity without mound building", and "Some conditions of mima mound building" present the more important conclusions of the study. Further studies of the development of the associated soils and vegetational formations will probably yield valuable results in dating maximum ages of mound colonies. Proponents of the opposed hypotheses of physical agency have lately based their contentions on the belief that the correlation of regional mound occurrences here made is faulty, but have not as yet shown valid sub-types of mounds to be separated from those here grouped into a single type, mima.

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SOUTHWESTERN WATER RESOURCES—THEIR CONSERVATION AND UTILIZATION

Morgan H. Rice
Assistant Vice President
Federal Reserve Bank of Dallas

In view of the scientific nature of this subject, its breadth and depth, and its significance to the future growth and development of the Southwest, it gives me, a mere layman, considerable pause in attempting to discuss it before this group. The late Will Rogers had a favorite saying "All I know is what I read in the newspapers." Paraphrasing that saying, All I know about the water resources of the Southwest and their management is what I have read in the excellent reports of such groups as the Board of Water Engineers, the United States Geological Survey, the Bureau of Reclamation, the Corps of Army Engineers, and the Soil Conservation Service. The information in these reports has given me an appreciation of the problems with which we are dealing and has aided in interpreting the significance of my observation about the condition of our soils and the use of our water resources.

It is generally true, I think, that we do not appreciate the significance of a vital resource until we begin to visualize a scarcity. When we face that possibility, we are sometimes aroused to the point where we try to do something about it.

In the Southwest, few physical factors have been or will be more important than water in defining our developmental pattern. In the past, many people have been profligate in their use of water because supplies seemed inexhaustible. The very abundance of water seemed to obviate the need for its conservation. During the past half century, however, area after area has experienced a scarcity of water. The diminishing water supply in relation to requirements is the outgrowth of the rapidly increasing population and extensive soil erosion, which has reduced the absorptive capacity of our soils, silted up our streams and reservoirs, and increased the intensity of floods. Fortunately, the several bodies of which I spoke earlier, through years of study, research, and investigation, have assembled basic information about the nature and extent of our water resources, and the need for their conservation, and in some areas have contributed much toward the solution of the immediate problems.

At the outset we should realize that precipitation, which is the source of all water, is affected by such varying factors as altitude, mountain barriers, prevailing winds, and the location of an area in relation to other land masses and to bodies of water. In the Southwest, we derive the major portion of our precipitation from the air masses which form over the Gulf of Mexico because we are shut off by the Rocky Mountains from the moisture-bearing winds of the Pacific. This condition determines the regional as well as the seasonal distribution of rainfall. During the winter months, air pressure over this region is generally higher than over the Gulf, causing an outward movement of winds which are displaced by cold and relatively dry air from Canada; in the summer, moisture-laden winds from the Gulf move inward over the land mass. Since these winds move north and westward up the several river basins and deposit their moisture as they come in contact with colder air masses, the largest amount of precipitation annually occurs in the eastern part of the region and diminishes at a fairly uniform rate from about 60 inches in eastern Louisiana to 10 inches or less in parts of western Texas, New Mexico, and Arizona. The seasonal variation in rainfall is most pronounced in arid western areas and smallest in the humid eastern areas. The maximum occurs generally in July and December in the land area adjacent to the coastline from New Orleans, Louisiana, to Houston, Texas; during the winter and spring months in north Louisiana, eastern Texas, and Oklahoma; and during the middle or late summer in most of the western areas. Even where the annual precipitation is adequate, its seasonal distribution often creates serious problems with respect to the management of water supplies and the production of crops and livestock. The concentration of rainfall in relatively short periods results in excessive moisture and heavy runoff with consequent floods at one season and a serious deficiency of water at another.

Basic to an understanding of our water problems is a knowledge of how water is stored for future use and what causes the loss of so much of the precipitation.

Rainfall is distributed into a number of channels. A portion is carried away immediately by streams and rivers; another portion is absorbed into the upper layers of the earth, where it will be available for plant growth; while a smaller amount filtrates far below the surface to become a part of ground water supply.

That portion of precipitation reaching streams and rivers is called surface water. Its extent is determined by the intensity of rainfall, by the rates of evaporation and transpiration which prevail in an area, and by the absorptive capacity of the land, which is influenced by its slope, the nature of its cover, and soil structure. Because of the differences in rainfall and physical conditions, the amount of runoff varies widely in the several sections. It declines from east to west, falling from an annual average of about 20 inches in the extreme eastern portion to less than one inch in parts of the western area. In Louisiana, where annual precipitation averages around 55 inches and high humidity reduces evaporation and transpiration, the runoff amounts to about one-third of precipitation, but in the western portion, where both rainfall and humidity are low, less than one-tenth of the rainfall reaches the streams and rivers.

The southwest region may be divided into three major surface water areas. From the standpoint of total runoff, the most important is the area drained by the Mississippi and its tributaries, which covers most of Louisiana, Oklahoma, and northern Texas. It includes the Arkansas, Red, Ouachita, and White Rivers and their tributaries, as well as the lower stretches of the Mississippi, and comprises about 25 percent of the total Mississippi drainage area.

The second surface water area is the Western Gulf Basin, which covers the southwestern corner of Louisiana, all of Texas except the northern portion, and the southeastern quarter of New Mexico. This basin includes the nine principal Texas rivers emptying into the Gulf of Mexico and is the only major surface water area falling entirely within the Southwest.

The third area, which includes Arizona, northwestern New Mexico, and a large section to the north and west is drained by the Colorado River and its five major tributaries. Like the Mississippi, the major portion of its flow is derived from areas outside the Southwest.

Stream flow records indicate that many streams in the Southwest either go dry in some seasons or that their flow drops to quantities insufficient to meet water requirements. At other times the flow increases to such an extent that severe flood damage occurs. To correct this situation and to make possible a fuller utilization of water, many areas have built storage facilities to aid in the regulation of stream flow, to store flood waters for use during seasons when the natural flow is inadequate to meet their needs, and in some instances to supply water for irrigation and hydroelectric power.

The impounding of flood waters in storage reservoirs is comparatively new in the Southwest. Yet, since the construction of Bachman Lake near Dallas in 1902-03, thirty-four major storage facilities have been constructed in Texas, with a total capacity of more than twelve million acre feet. Of this total, twenty-five are single purpose reservoirs: fifteen are used to supply municipal and industrial requirements; four, for the development of power; and two each for irrigation, recreational, or flood-control purposes. The remaining nine, including the larger reservoirs, have multiple uses. Numerous dams are now under construction or plans for them are being formulated.

Rainfall and surface water are supplemented in many areas by water drawn from underground sources. Over a very long period, precipitation filters down through the soil profile and great stores of water collect in strata of absorptive materials far below the earth's surface. Frequently, these underground reservoirs extend over wide areas and, in some instances, move horizontally through the absorptive strata, generally flowing in the same direction as surface streams. A portion of this underground supply is discharged through springs and seeps, but, in general, this natural loss is balanced by the downward filtration of water from the surface, and water tables remain stationary if undisturbed.

The large ground water supply in the arid portions of the Southwest made possible the development of those areas and continues to support their economic activity. Even in the portions of the region where rainfall is adequate and runoff is large enough to meet most demands, many municipalities and industries tap underground supplies because the flow and quality of water from that source does not vary as much as water in surface streams. Moreover, supplies from this source are affected little by droughts, seldom vary in temperature, and can be developed quickly and at relatively little expense. Some areas, however, are unable to depend upon ground water as a source of supply either because it is not available in adequate quantity or has a high mineral content.

The Balcones fault zone, which extends in a belt of varying width from a point northeast of Austin southwestward to the vicinity of Del Rio, is one of the most productive sources of ground water in Texas. Extensive underground reservoirs are fed by the perennial streams which carry both rain and spring water down from the Edwards Plateau. These spring-fed streams are estimated to add about 150,000 acre feet per year to the fault zone reservoirs. The ground water of the fault zone moves in a southeasterly direction, and the principal outlets from the reservoirs are the series of large springs along the southern and eastern edge of the zone. These springs are the sources of good-sized rivers and creeks which furnish water to many towns and cities in south Texas.

The underground reservoirs of the Coastal Plains are another important source of ground water. Although there are a series of underground reservoirs within this major area, they do not appear to be connected; and there are sections, such as the Lower Rio Grande Valley, where underground supplies of usable quality do not exist. This area extends from the Rio Grande eastward across the southern portion of the United States and includes all of south and east Texas, as well as Louisiana. Water from this source is used for irrigation in the Winter Garden Area below the fault zone and for a considerable part of the rice acreage near Houston. In addition, several coastal and eastern Texas communities secure water from this source to fill most of their public and industrial requirements.

In east Texas, the heaviest withdrawal of ground water occurs in the Lufkin-Nacogdoches area where it is used to meet the needs of Lufkin, Nacogdoches, and several smaller communities, as well as to fill the large requirements of the paper industry located in the area.

In the High Plains, a large supply of usable ground water is found in the layer of sands and gravels which cover most of the area just below the surface and extends down to a depth of between 200 and 300 feet. This formation is underlain by a layer of older rock which also contains deposits of water, but the water in this older formation is so highly mineralized that it is unfit for most uses. Since the upper formation has been eroded down to the bedrock on the eastern and western boundaries and through the center along the Canadian River, it is cut off from all underground streams which might bring water from the Rocky Mountain Area, except possibly through the older rock layer. The Texas Board of Water Engineers has stated that if water moved upward through this layer of older rock into the upper layer of sands and gravels, it would become highly mineralized. It has concluded, therefore, that since the water in the upper formation is not highly mineralized, the fresh water in this formation is supplied from the rain and snow that fall on the surface. The greater part of the precipitation in the area is lost through evaporation, transpiration, or runoff, but a very small part does filter downward to the underground pools.

Although ground water surveys have not been made in all areas of the Southwest, it is known that important though small deposits of ground water exist in other parts of the region. In Texas, there are small supplies in the northern and eastern parts of the State. Ground water supplies in the northern and western parts of Louisiana are generally similar in character and extent to those found in eastern Texas. The potentialities of ground water in New Mexico and Arizona have not been explored completely, and the extent of known ground water is very limited. In Oklahoma, meager to moderately abundant supplies of water are obtained from underground sources, although much of this water is highly mineralized, particularly in the more arid western portion.

The available facts would seem to suggest that thus far few areas in the Southwest have suffered from a deficiency in water supplies. The development whose implications have not been given adequate consideration is the tremendous increase in the demand for water. Population growth, together with the greatly increased per capita requirements under modern living conditions, has been a factor in water demand, but of much greater importance has been the rapid expansion in the use of water for irrigated farming and for industrial purposes. In Texas, for instance, water demands in the past 50 years have increased more than 7,000 percent, although population has increased less than 300 percent. Requirements increased significantly during the war and postwar periods as population shifted toward the urban areas, industrial plants were established or expanded, and irrigated farming was extended. The farming area under irrigation in Texas rose from 895,000 acres in 1939 to 2,400,000 acres in 1947. In some instances, the water requirements of newly established industrial units are equivalent to those of cities with a quarter to half a million people. In fact, these developments have focused attention on the fact that withdrawals of water have not been in accordance with the principles of best utilization. The removal of water from ground sources has been at such a rapid rate that a decline in water levels or artesian heads has occurred in many areas. The decline has been particularly marked in the High Plains, Lufkin-Nacogdoches, and the Winter Garden areas, while the reduction in artesian pressure in the Galveston area has permitted the intrusion of salt into the supply, necessitating the development of a new source. At the same time, it is estimated that over three-fourths of the surface water has been allowed to escape into the Gulf. Moreover, communities depending upon surface water have had difficulty in securing continuous supplies and in maintaining storage facilities at the constructed capacity because of the rapid silting of reservoirs.

The problems of water conservation and utilization are complex and diverse. In its movement either above or below the surface, water follows natural channels or slopes extending over wide areas, and frequently several communities, states, or even nations are concerned with a single source of supply. The problems are further complicated by the multiplicity of interests found within each community and by the great diversity of physical conditions encountered in many water supply areas.

Upland farmers are interested in retarding the movement of water across the surface of their fields in order to check the rate of erosion and in retaining as large a portion as possible of the precipitation which falls on the land so as to assure a supply of stored water for drought periods. Farmers in lowland sections may be primarily interested in preventing deposits on their land of silt and sand washed down from the hills and in the improvement of surface and internal drainage. Municipalities and industrial users are directly concerned with the provision of an adequate supply of unpolluted and good quality water, the prevention of floods, and the disposal of waste and unwanted water. Operators of hydroelectric plants and water transportation facilities are faced with the problems of maintaining a steady flow of water and preventing destructive silting of lakes and streams.

In spite of the diverse and often conflicting interests, however, the problems are interrelated and can best be solved if considered collectively. In order to assure that all interests will be attended, it is frequently necessary to approach these problems on a regional or even national basis, which permits compromise of the divergent interests and the coordinated conservation and development of the water resources.

A basic consideration in determining a feasible program should be the relationship of water to the land, because it is on individual farms and ranches that the first steps should be taken. The control of surface water at its source is essential to the ultimate solution of virtually all other problems of water conservation and control. Here, effective action can be taken to retain increased proportions of precipitation in the areas where it falls, reducing soil erosion and the rate of water runoff, increasing the filtration of water to underground reservoirs, and aiding in the prevention of floods, the silting of streams and reservoirs, and the deposition of soil on lowland areas. The necessity of initiating measures to achieve these desirable objectives is emphasized by the steady deterioration of soil fertility through the years. Over large areas of the region the protective cover has been stripped away, exposing the land to the beating action of rain and increasing the rate of erosion. The runoff of water into streams and rivers has been speeded up and flood damage has been intensified. Silting, which results from this erosive process, has impaired navigation, partially filled many storage reservoirs, and reduced the productivity of lowland fields on which it was deposited.

Through the establishment of a coordinated soil conservation program on individual farms, it should be possible to bring about a material improvement in existing conditions within a reasonable period and ultimately to provide for the solution of many basic problems. By increasing the absorptive capacity of the soil through use of such conservation measures as plowing under green manure crops, the use of commercial fertilizers, or other measures which would improve the structure and internal drainage of the soil, the rate of runoff and erosion could be reduced. Where such measures are needed, the construction of terraces or diversion ditches, contour planting, and the use of cover crops or the restoration of sod or forest cover on erosive slopes would slow the movement of water across the land. The building of farm ponds and tanks would reduce the volume of water entering streams during periods of heavy rainfall and would provide an additional supply of water for use on farms during dry periods. These measures, in addition to conserving the available supply of water and bringing about more efficient utilization, would be effective in increasing the volume of agricultural production. Moreover, such measures would act to increase the downward filtration of water to underground reservoirs. Erosion also would be reduced, minimizing the problem of maintaining navigable streams and usable municipal water supplies.

Great progress has been made in the organization of individual farmers into soil conservation districts and in supplying them with the technical advice required to carry out a coordinated conservation program. Conservation measures have been established on a considerable portion of the land in farms, and the effectiveness of these methods in checking erosion and runoff, in improving the soil structure, in increasing land fertility, and in improving water utilization has been demonstrated clearly. The establishment of conservation measures on individual farms, however, is far from complete, and the need for expanding this program to cover the entire region is urgent. If the soil conservation program in each district were coordinated more completely with flood control, drainage, and water improvement work, the progress of each program would be accelerated. While the job of conserving and improving the utilization of soil and water must be started on individual farms, it is done most effectively when attacked on a watershed basis.

Closely related to the problem of controlling surface water and conserving the soil is the progressive depletion or deterioration of ground water supplies. The effects of wasteful exploitation of these resources in many areas have been intensified by the reduction in the recharge of underground reservoirs, due to the removal of the native cover and the deterioration of the soil structure. Although prolonged periods of below normal rainfall have contributed to the decline of ground water supplies in many areas, the resulting deficiency in recharge could have been offset partially during years of above average precipitation if the downward filtration of surface moisture had been increased. Even if the rate of recharge of ground supplies should be increased through the application of soil conservation measures, it might still be necessary in some areas to limit the withdrawal of ground water if supplies are to be maintained permanently. Although it appears unlikely that the supply of ground water will be exhausted completely in any area in the near future, continued declines in the water level or artesian pressure may require the boring of progressively deeper wells, which eventually may raise the cost of water withdrawal to prohibitive levels.

The large and expanding area of farm lands under irrigation has created some serious problems with respect to water utilization and conservation. In districts where irrigation is already established, problems have arisen in regard to the efficient use of water. In some cases, a portion of the inadequate supply is often wasted either through loss from the irrigation system itself or through the unwise use of water on the land; while in other instances, the productive capacity of the land has been reduced by raising the water level or increasing the salt concentration in the soil. Construction of improved irrigation systems would reduce the loss of water through seepage and evaporation, and the adoption of improved irrigation practices already known will direct more water to plants and reduce losses in the fields. To solve this problem completely, however, additional research is needed to discover the water requirements of various crops and the yields derived with varying applications of water. Additional careful study also is needed of the mineral content of water used for irrigation and the effect of these minerals on growing crops and land productivity.

Falling water levels in underground reservoirs, combined with the tremendous expansion in water requirements, bring to the forefront the necessity of increasing the downward filtration of water to underground pools and of controlling withdrawals of water from ground supplies. They are also indicative of the extent to which the region must depend upon surface streams to meet future increases in water requirements. Under these circumstances, consideration should be given to the problems of management and utilization of surface streams, such as control of destructive floods, stabilization of stream flow, reduction or elimination of pollution, and, where feasible, development of hydroelectric power as a means of distributing costs and supplementing the existing power resources.

A major problem is the recurrence of destructive floods, resulting primarily from the concentration of rainfall within relatively short periods. These floods which continue to cause tremendous loss of life and property each year are produced chiefly by tropical or semitropical storms which enter the southeastern portion of the area from the Gulf of Mexico or across the northeast corner of the Republic of Mexico.

In that portion of the region lying east of the ninety-ninth meridian drained by the Mississippi, floods are a serious problem each year, but considerable progress has been made in their control. In the western Gulf drainage area, destructive floods occur in the lower reaches of the major streams on an average of once in every four or five years. Reservoirs in the upper portions of these streams have reduced floods somewhat, but these facilities have little or no effect on the flow resulting from heavy storms below the reservoirs. In the Colorado River drainage area in the western part of the region, the construction of reservoirs has about eliminated the danger of floods in the lower portions of the river.

Flood control works in the Southwest are of three general types: storage reservoirs to impound flood waters for later release; channel improvements to increase capacity or to facilitate water flow; and levees to protect bottomlands and to hold the streams within relatively narrow limits. Storage reservoirs generally are believed to provide the most satisfactory method of control if the terrain permits their construction and if the impounded waters can be put to multiple uses, thereby reducing their costs. Moreover, their ultimate effectiveness depends on the reduction of silting through soil conservation measures. Channel improvement alone generally does not afford adequate protection from floods, but this development has been a valuable and in some cases a necessary supplement to other flood control measures.

Much can be done to increase the effectiveness of these flood control methods if and when the comprehensive soil conservation practices are put into effect on farms and ranches over the whole region. Supplementary practices, such as construction of numerous detention reservoirs, gully control structures, flood water diversions, revegetation of critical flood and sediment areas, adoption of roadside erosion control measures, and stream channel improvements, would aid in reducing the amount of runoff or facilitate the movement of water in streams.

Another serious problem arising out of the irregularity of stream flow is the provision of continuous supplies of water to meet the needs of many municipalities, industries, and irrigation farmers. Frequently, water users depending upon streams for their supplies find that the flow of those streams drops to such low levels during extended periods of drought that it is inadequate to meet their normal requirements or that the quality of the water deteriorates to the point where it is unfit for many uses. Since a considerable portion of the surface water of the Southwest is allowed to escape into the Gulf each year, it appears probable that the requirements of most communities could be filled if the flood flow were stored for later use. Although many storage reservoirs have been constructed in the region, it is becoming apparent that many more may be needed if the stream flow is to be regulated and an adequate supply of water assused. Successful control of stream flow and maintenance of storage reservoirs, however, will depend in part upon slowing the rate of runoff and increasing the infiltration of water by the application of soil conservation measures.

Other associated problems relate to the control of stream pollution resulting from the irregularity of water flow, and the development of hydroelectric power. While time will not permit a discussion of them, it should be stated that they deserve important consideration in the formulation of plans covering the conservation and utilization of our water resources.

In summary, let me say that a study of the water resources in the Southwest and their utilization reveals disturbing trends. Ground water resources in areas where they appeared inexhaustible have been used with almost reckless abandon as population has increased, new industries with large water requirements have been established, and farmers have turned to irrigation as a means of increasing crop production. During recent years of exceptionally heavy water consumption, water levels in underground reservoirs have fallen lower and lower, indicating that downward infiltration of water from the surface has been insufficient to replace the large withdrawals. Numerous communities without adequate ground water supplies turned to the construction of surface reservoirs. These reservoirs have contributed greatly to the water supplies of the region, but with the passage of years it has been discovered that their constructed capacity has been reduced significantly by rapid silting. Associated with these developments have been: (1) the intensification of floods; (2) the silting of streams and channels resulting from improper land use, increased water runoff, and soil erosion; and (3) the increased pollution of streams and certain underground reservoirs. A continuation of these trends which reflect waste and misuse of the region's water resources may mean that the Southwest will soon reach the limits of its expansion and ultimately may even face a reduction of its industrial activity and farm irrigation.

On the other hand, study of the water resources of the Southwest need not lead only to a discouraging conclusion. Great potentialities for the region are inherent in its water resources, provided a long-term program of development, conservation, and proper utilization of water is effected promptly. Most areas probably receive sufficient rainfall to recharge underground reservoirs or at least to check the rate of decline in water levels and to assure unusually large quantities of surface water, provided maximum quantities of water are stored and properly utilized.

The several State and Federal agencies have already completed much of the foundation work for the development of a coordinated water conservation program, and considerable progress has been made in establishing soil conservation practices and the necessary surface reservoirs. The steps taken thus far indicate that progress is being made, but an objective appraisal also indicates that these steps represent only segments of the broad problem of assuring adequate water supplies for the Southwest.

The seriousness of the water problem and the importance of water to the further growth of the Southwest emphasize the need for the formulation and effectuation of a comprehensive program for the conservation, management, and utilization of the region's water resources. There is perhaps no more important basic problem confronting the people of this region today than the problem of its water resources. The most effective results toward the solution of this problem can be obtained only through the close cooperation and coordinated effort of all interested groups working in harmony to achieve the common objective.

INTERDEPENDENCE OF PHYSICAL AND SOCIAL SCIENCES IN THE ATOMIC AGE

J. W. Baldwin
University of Texas

In an address at the installation of the new President of the University of Illinois on May 16, 1947, Chancellor Robert M. Hutchins of the University of Chicago made the following pronouncements:[1]

> It is principles, and everlastingly principles, not data, not facts, not helpful hints, but principles which the rising generation requires if it is to find its way through the mazes of tomorrow.
>
> The American educational system mirrors the chaos of the modern world. While science and technology, which deal only

[1] "The Education We Need." Henry Regnery Co., Chicago.

with goods in the material order, are flourishing as never before, liberal education, philosophy, history, and theology, through which we might learn to guide our lives, are undergoing a slow but remorseless decay.

It would seem that Chancellor Hutchins holds with many the conviction that the welfare, and perhaps, even the survival of humanity depend almost exclusively upon the mastery of the humanities in general and the social sciences in particular. It would be impossible for either the social scientist or the physical scientist to accept such an appraisal of the importance of the social sciences. The social sciences are indispensable as a factor in the solution of our problems, but the same is true of physical sciences. [2]

On the other hand, there is a strong tendency on the part of many physical scientists to look with considerable disdain on the potentialities of the social sciences as compared with those of the physical sciences. The thesis of this treatise is that neither of these two subject-matter domains has the key to the specific for all of our individual and social ills, and that even both of them working independently cannot save society from dissolution, or disintegration, if not even extinction.

It is not difficult to agree upon the fact that we do not now know how to save ourselves from catastrophe, even in the face of the fact that it seems that we are to serve as our own executioners. It may be that we shall not be able to do so even when we join all of our forces and facilities in a united effort to avert disaster. But such a plan seems to promise more hopeful possibilities than any other that has been suggested so far. It is worth giving a trial since the stakes are so high and since we could not possibly make matters worse by doing so.

For more than two decades the writer of this paper has devoted a considerable percentage of his time to an effort to increase the value of the contributions of the social sciences through a closer correlation of subject-matter and activities concerned with the individual disciplines in this group of kindred sciences. Many others have been intensively interested in this movement. It has centered chiefly in the correlation of content and procedures in applied phases of social science. Those who have worked on this project are beginning to realize greater returns on their investment than they had dared to hope for in a brief span of years. Those who have devoted time and effort to this movement have discovered that even when the materials and techniques of all of the social sciences are brought to bear upon the solution of problems which are usually assumed to reside entirely within the social science domain it is also necessary to draw heavily upon physical science for additional knowledge and skills which they alone can provide. This discovery helped to point up the need of a still broader base from which to map the strategy for an attack upon problems in every area of human concern.

Many of those who have been chiefly concerned with the physical sciences in recent years have discovered the advantage of a closer

[2] The term, **physical sciences** is used in this paper in its broadest connotation, and is assumed to include all of the sciences which deal with material phenomena.

association of all of the physical sciences, especially those elements known as the applied sciences, in their attempt to bring content and methods from all of them to focus simultaneously on projects which have heretofore been considered the concern of only one of the subdivisions of this field. Like the social scientists they have been agreeably surprised with the success achieved through such correlation. As a result of the discovery of so many overlappings and supplementary aspects of these individual disciplines a new term, general science, has been adopted to designate the use of kindred aspects of these related sciences in a unified approach to the solution of many problems which did not yield to application of the materials and techniques of an isolated division of this area. But even when all of the physical sciences are utilized in a unified attack on many such problems it has been found necessary to utilize many aspects of the social sciences to supplement the contributions which the physical sciences can make; thus further emphasizing the need for closer correlation of the physical sciences with the social sciences.

The movement toward the simultaneous employment of materials and techniques of the separate subject-matter areas in each of the two broad fields has been delayed and hampered by the fear of many specialists that the individual subject with which each is concerned might lose its identity or at least be reduced to the status of handmaid to some other science or combination of sciences. This is sure to delay the adoption of a unified or correlated, and synchronized attack by social and physical sciences on the urgent problems and issues which threaten our very existence, and which cannot be resolved in the absence of such cooperation. We seem to find ourselves more concerned about the welfare of our special subjects than about the welfare of humanity.

It was necessary to set up fields for narrow specialization in order to permit the specialist in each field to limit his territory to an area small enough to make it possible for him to explore it intensively. We shall continue to need many specialists who devote their entire energies to one small segment of the total domain of the sciences. But the tendency to specialize narrowly has become too nearly universal. We need many scientists who are trained to see the interrelationships, overlappings, and supplementary aspects of all sciences, and who have a command of the means for focusing the contributions of all these sciences in a single undertaking simultaneously, irrespective of the sources from which the contributions may be derived. It might not be very far from true to say that we need a lot of trained people who are specialists in things in general. At least one nation has been encouraging this kind of training with grants and subsidies in recent years because it is convinced that they could render a significant service to the nation in peace and in war which could not be secured from a combination of the contributions of narrow specialists. That does not mean that narrow specialization is discouraged in any way.

In order that social and physical scientists may be able to work cooperatively it is desirable that each try to understand the point of view of the other. They have many things in common. Both are vitally interested in the search for truth. Both try to be objective in their procedures and conclusions. Both respect exact scholarship. They see eye to eye in many other respects, probably in most of the essential aspects. Where they differ it is more likely to be a difference in emphasis on various elements of their ideals and practices.

For example let us assume that the social scientist is more concerned than the physical scientist about what Dr. Hutchins calls principles, and that the physical scientist is more concerned about data, facts and objectivity than he is about principles and social responsibility. If these assumptions should be correct, and they very likely are not altogether so, this would not mean that either has no interest in any one of the factors named. It merely means that there may be a difference in emphasis on some factors. An approach to better understanding and more willing cooperation might be found through a study of the values inherent in what is held most sacred by representatives of both fields. We would usually end up by concluding that all factors are important and indispensable, if not of equal significance.

It may be that the physical scientist places a higher value on the discovery of truth than on the application of his findings to the pressing problems of society. It is well known that many social scientists are weak at this point also. But perhaps they have better facilities than some physical scientists for making such adaptations, especially when implementation is to be made in the improvement of human relationships. But it would seem that it should not be difficult to reach agreement on such a point as this if study of the matter is pursued to its logical conclusion. All scientists usually find themselves in agreement when they push their investigations to the limit. But it is not necessary to reach complete agreement in order to work cooperatively. In many instances it is best for the specialist in physical science to discover the truth with the assistance and sympathetic observation of the social scientist, and then let the social scientist make the application with the assistance and interested observation of the physical scientist.

In any case it is fatal to assume that the truth in itself will solve our problems. It is misleading to quote the Master Teacher as having said: "Ye shall know the truth, and the truth shall make you free," without adding the qualifying clause with which he prefaced this half of the sentence. What He really said in St. John, 8:31-32 was: "If ye continue in my word, then ye are my disciples indeed; and ye shall know the truth, and the truth shall make you free." That the last half of the sentence is wholly contingent on the first clause is indicated by the fact that special stress is put on the word, then. Knowledge of the truth without doing anything about it may even enslave us. Knowledge of the truth is a sine quo non for doing something about it. But it loses its value if we stop with the discovery of the truth. Knowing the awful truth about the atomic bomb has not made us free. In many instances a knowledge of the truth does nothing but scare the daylights out of us.

How Can Physical and Social Sciences Pool Their Efforts?

There are innumerable ways in which the social and physical sciences can unify and synchronize their efforts and resources to great advantage to both groups and to society which is served by both. Only a few examples can be cited in the limits of this paper.

As an example let us consider the desirability of securing freedom. It seems that it is fair to assume that the physical sciences are better equipped than the social sciences for furnishing us the mechanical instruments and the technological devices to help us to achieve our freedom from illness, privation, military aggression, and financial insecurity, while the social sciences can probably contribute more to achievement of freedom of speech, worship, and conscience. If physical science can contribute more to the achievement of freedom it is likely that social science can contribute more to the intelligent use of our freedoms. There is not much to be gained from freedom which we do not know how to utilize to the best advantage. It is possible to use our freedom for our own destruction.

Physical science may be able to contribute more to raising the standard of living, while social science may be able to teach us more about how to live usefully and happily. Social scientists can attack the problem of the causes of individual and group differences through study and classification of motives, drives, instinctive tendencies, mores, taboos, and so on, while the physical scientist will be able to attack the problem through a study of genetics, physiology, biology, and other sciences through the laboratory techniques which are characteristic of research activities in that field. The natural sciences can provide a scientific basis from which the social scientist will be able to project his further study of human relations. The natural sciences can shed some new light on racial traits, individual differences, and human motives as they are influenced by physiological variations, vitamin or other food deficiency, climate, and several other factors. Men of good will result in part from influences other than purely social phenomena.

It is not difficult therefore to understand how the social sciences and the physical sciences can profitably cooperate in dealing with such problems as relations between labor and capital, employment, vocational guidance, industrial management, human engineering, warfare, social control, adaptation to changed conditions, production and consumption, agriculture, tolerance, human nature, conservation of human and natural resources, security, mental hygiene, youth delinquency, and improvement of heredity and environment. The list could be extended almost indefinitely. Much of the cooperative research by physical and social sciences should be sponsored by public funds in order to make sure that the interest of society is served.

Not only do we find that social and physical sciences have much in common in content and method, but an analysis of the nature of several of the sciences discloses that several of them are both physical and social sciences. To name only a few, the list would include agriculture, geography, psychology, psychiatry, hygiene, military science, industrial management, and commerce. In fact all science is one and was earlier considered a single unit of knowledge. It has always been helpful to look at problems from the point of view of several sciences rather than from one only. In recent years the artificial walls between subdivisions of the physical sciences and also those between individual social sciences have become less distinguishable, and the same thing is now happening to the wall between social and physical sciences.

Many of the most important discoveries in research in recent years have occurred in the areas where the sciences merge or overlap. Unfortunately some of inestimable importance to the social scientist have come from the laboratories of the physical sciences without advance notice, making it impossible for the social scientist to cooperate in the implementation of the information to the best interest of all concerned. Often it happens that by the time the information becomes available to the social scientist it has already been channeled into the pursuit of unworthy objectives. We have been willing to pay dearly for scientific production in warfare and have thus frequently caused the results of findings to be used first for destructive purposes. We need more research directed toward winning the peace. We must achieve local, national, and international citizenship. Natural science must find ways to assist social sciences in production of civic values which the social scientist will be able to put to the best use. The frontiers of knowledge are probably to be found at present in the areas where social sciences approach nearest the domains of physical sciences. The applied sciences in all categories seem to offer the best medium for cooperation among the several areas.

We must never forget that we live in a physical and social environment neither of which would have any value without the other. Lack of sympathetic understanding on the part of specialists in the two fields can only lead to catastrophe. We cannot hope to agree on every minute detail. But it will be easy to agree on broad, general principles, objectives and procedures. We must work hand in hand in setting up goals and in making procedures developed in one area available to specialists in the other. Each can help the other to see the potentialities and the significance, and even the dangers of discoveries. There is no point in doing well what is not worth doing at all. By working together it will be possible for all to devote their energies to worthwhile undertakings without wasteful duplication. Too often the individual specialist in social or physical science not only does not know what is going on in the other broad field, but is unaware of what fellow specialists in closely allied areas are doing. We cannot hope to build a better world through the medium of isolated attacks upon our pressing problems. Social welfare must from now on be the objective of all sciences. We have available much valuable material which has not been collected and unified or integrated for practical application to social problems. We need to put our findings together to acquire a total picture with all of its implications, and potentialities. And we must never permit our admiration for scholarship to cause us to lose our sense of obligation for good citizenship. Contempt for other sciences and other scientists must give way to an attempt to utilize all sciences and all other branches of learning in a concerted effort to render unselfish service to mankind. There will be enough honors to go around, if honors should have any part in our aspirations.

On every hand we see signs of more and more willingness to cooperate in an effort to increase the contributions of each science and each scientist, as well as those of the combined effort of all. Time is pressing. Can we get our forces martialed in time? We must find some defense for the Frankenstein which we have created in the form of atomic bombs; and it will have to be in the realm of moral, social, and spiritual values. Politics, and physical instruments of warfare are not adequate. Both social and physical sciences must work cooperatively, and rapidly.

It is fortunate that the sciences in both fields are learning to employ procedures which previously were thought adaptable in only one or the other area. Doctors and psychiatrists are using principles and procedures from both fields. Employers are calling on both to furnish information concerning prospective employees. In some instances the employers are more concerned about moral and social equipment of prospective employees than about their vocational preparation. They soon learn that expensive equipment and machinery cannot function properly in the hands of unprincipled men. Specialists in both fields employ such procedures as the historical method, analysis and synthesis, the observation method, the experimental method, the statistical treatment of data, casual-comparative method, and many kinds of testing and evaluation. Every physical science has its historical origin and evolution which the physical scientist must master. Every social science has its physical environment and instruments which the social scientist must utilize.

Someone has said that scientific research needs a soul. If so, perhaps social science can contribute something here in return for a body which physical science can provide. But physical science seems to be rapidly finding a soul if it lacked one. The scientists who created the atomic bomb were the first to recognize its social or anti-social potentialities and to devote themselves to the task of trying to turn the information back of its creation into productive social channels and away from destructive purposes. McArthur was probably right when he said that our problems in the future will be largely theological. We certainly need such contributions as can be made by religious leaders in our effort to direct the labors of scientists into proper channels. The natural scientists need the faith of the social scientists that the right will eventually triumph. We must work fast to replace hatred, fear, and competition with faith, altruism, and love for all mankind. The social sciences can provide the framework or pattern and set up worthy goals, while physical sciences can furnish the means, tools, procedures, and measuring devices. The social sciences should probably take the lead in the final evaluation of outcomes. Some have claimed that our troubles stem chiefly from the fact that the social sciences have lagged behind the physical sciences. This may be true in some measure, but the chief trouble arises from the fact that the two groups have not been made to function as a unit in attack on our problems and issues.

How Can We Secure Cooperation Among the Scientists?

In the long run we shall have to depend on the proper preparation of youth to secure the kind of workers in all branches of science if we are to make these sciences serve humanity to the best advantage.

Much must be done with present workers as stop-gap measures because the demand will not wait. But youth can be trained to attack problems cooperatively before they acquire loyalties for individual subject-matter areas, and that with much less effort than that required to convert adults to a new way of looking at life's demands.

The writer of this paper has been chiefly concerned with the preparation of teachers who will guide their students in the integration of the elementary phases of the social sciences for the purpose of providing experiences which will acquaint them with the techniques required in dealing with social problems and issues in natural, life-like situations. For example, they learn how each of the different social sciences contributes to the successful management of a community enterprise, such as the construction of a new school building.

The necessity for the consideration of geographical information in the determination of the location of a school plant is too obvious to be overlooked. Historical trends with reference to the acceleration of the growth of population, and the direction of its expansion demand careful consideration in the choice of the building site and the size of the structure. In some communities racial problems are of sufficient magnitude to require the employment of the subject-matter of sociology in the attempt to decide upon the most satisfactory location with reference to various types of residential areas. The content of economics will supply information relative to the problem of financing the project and the proper distribution of the cost among direct and indirect beneficiaries. The entire undertaking will constitute a civic undertaking in which the principles of community civics will be employed in each cooperative effort and in every sacrifice incurred in service to the community.

But when contributions of all the social sciences have been utilized in such an undertaking, the students and the teachers discover that the project cannot be completed without calling upon the content and procedures of physical sciences and other branches of learning. Community hygiene must be employed in selecting a sanitary site and in provision of sanitary equipment. Problems involving the subject-matter of physics, architecture, mathematics, mechanical engineering, and other sciences play a very significant role as the undertaking goes forward.

It is significant to note that materials from many areas in both social and physical sciences must be utilized simultaneously, and not one at a time. Physical and social science constitute a two-horse team. Nothing of value is accomplished if one pulls at one time and the other at a different time. It requires the application of all forces at the same time.

In a unit on home life students and teachers soon learn that almost all of the social sciences and almost all of the physical sciences have to be integrated and synchronized to make an intelligent, effective treatment possible, and that seldom, if ever, are the materials of a single subject alone employed in treatment of a social problem.

In the traditional school students become so accustomed to unorganized, piecemeal study of life problems that it is almost impossible for them to make a satisfactory approach to the solution of such problems through the employment of information and skills acquired in isolated, unrelated, unsynchronized, and consequently, unnatural consideration in school subjects. It is extremely desirable that they deal with life problems and issues in school in the same manner which is required to deal adequately with them outside of school. It is hoped that the new approach through the integration of contributions from all subject-matter areas in dealing with these projects in school will result in trained workers who will be able to utilize information and skills, regardless of the subject in which they reside, in the solution of problems confronted in post school life.

Neither the social sciences nor the natural sciences can furnish us all of the information, skills, and principles which are required to master ourselves and our environment. Nor can both do so in the absence of cooperative, unified effort under all circumstances and at all times.

If these assumptions are correct it is not difficult to understand that the interdependence of social and physical sciences is real and vital, and that it would be tragic to fail to realize this fact immediately, and to work speedily on the problem of bringing them into closer unity in collaboration and objective.

THE BIOTIC COMMUNITY CONCEPT AS APPLIED IN HISTORICAL GEOLOGY

Walter P. Taylor, Leader
Texas Cooperative Wildlife Unit *
College Station, Texas

Although the paleontologists have given years of study to the significant records of the past, it has remained for the ecologists to point out one of the essentials to a clear understanding of conditions during geologic times. Note the following from Clements (1916, p. 319): " . . . it seems clear to the ecologist that the correlation of the land vegetation and fauna has scarcely begun, and that it must hold a future of peculiar attractiveness. Naturally, a few of the outstanding relations, such as that of mammals to the appearance of angiosperms and especially grasses, have been pointed out. No adequate treatment of this subject is possible, however, until the interaction of plant and animal communities at the present time is much better understood. Indeed, it seems certain that this will involve not only the articulation of distinct but associated plant and animal communities, but the recognition of actual biotic communities, in which certain plants and animals are at least as closely and definitely interdependent as the plants or animals are among themselves. It seems certain also that these biotic communities will prove to have an organic development and structure, such as has already been shown for plant formation." Later events seem

* Fish and Wildlife Service, U. S. Department of the Interior; Agricultural and Mechanical College of Texas; the Texas Game, Fish and Oyster Commission; and the Wildlife Management Institute, cooperating.

to be affording abundant proof of the accuracy of Clements' predictions. Osborn, likewise, has pointed out (1910, p. 45) that close geological synchronism requires comparison of the entire fauna and flora.

Perhaps it will be well to review some facts and observations in the field of historical geology, with the object of testing out the interdependence of plants and animals through time. By reading the record aright, a glimpse can be obtained here and there of the unfolding panorama of soil and topography, with the associated plant and animal life that went with it.

It is altogether likely that the earliest organisms were not plants nor animals but plant-animal in nature. They probably exemplified, in their own relatively simple organization, the primitive counterpart of the modern biotic community. As differentiation proceeded, plants and animals, as such, were separated off. All available information regarding plants and animals in the present suggests that from the beginning there must have been interrelationship and interdependence between plant-stuff and animal-stuff.

The impression of a plant fossil, perhaps of somewhat questionable status, occurs in Ordovician **(Protannularia)**, but the first unquestioned evidence of plants occurs in the Middle or Upper Silurian of Australia when ferns and their allies are unmistakable. In Devonian the ferns, club mosses, horsetails and primitive gymnosperms appear. Coactions of plants on plants were doubtless abundant in Carboniferous, as the presence of decayed material indicates presence and abundance of bacteria. Some of these primitive biotic communities are still of great significance to man—as the oil and gas series, some at least of the limestone and even iron ore, are very largely of organic origin.

It is extremely probable that there were important food and shelter relations between the stegocephalian amphibians (dominant animal life on earth during Carboniferous and early Triassic) and their plant and insect associates.

The land animals of Paleozoic times were mostly insects, scorpions, and primitive creatures of the cockroach, dragon fly and grasshopper types. All these animals, some of them very large, were undoubtedly closely related, in a functional sense, to the vegetation of their day.

In these ancient times insects were apparently the only flying animals. Some insects remained of large size until reptiles appeared. Then their size dropped to about what it remains at present.

Appearance of higher flowering plants in Mesozoic (Cretaceous or possibly a little earlier) indicates development, at about that time, of rather important and possibly obligatory coactions between plants and their pollinators, the insects. Analogy with the present day suggests the probability that the development and further evolution of the flowering plants may have depended to a considerable degree on the insects.

There is a possibility that the appearance of the mammalia in Mesozoic was associated with development of higher flowering plants, possibly, in part, through food or shelter relations.

Appearance, in Jurassic and Cretaceous, of birds, introduced a whole new series of coactions, namely those between the birds and their animal, and especially plant, associates. As at present, so then, the birds must have been dependent on plants, to a considerable degree, for food and shelter. Plants must have relied on birds for a certain amount of pollination, as well as for seed dissemination in certain instances.

Early mammals are presumed to have fed on insects. J. C. Merriam was of the opinion they could not have fed on vegetable food because of their lack of grinding teeth. Mammals with tritubercular teeth, however, could have eaten herbs.

In his great book on "The Age of Mammals," Osborn (1910) traces in considerable detail the interrelations of mammals to their environment, especially in Cenozoic times. Nor does he omit the plants, but tells, in a very convincing manner, the story of how they were related to the animals which largely lived upon them.

As pointed out by Osborn, it is assuredly true that to a certain degree animals mirror their environment. A jerboa or kangaroo rat like creature is almost certainly an inhabitant of an arid area. A tree squirrel shows that forests were present.

Extensive forest tracts are also clearly indicated (in horses, for example), by the short-crowned teeth, short heads, and usually short heavy limbs that go with a browsing habit. Grassy plain and desert are indicated by the long-crowned teeth so necessary to grind up the harder siliceous leaves of the grasses, also by the long-headed types adapted to secure food by grazing from the ground rather than browsing from bushes or trees. With these characters are associated light and long limbs to secure speed in getting over an open plains country. Flight from enemies and cross-country journeys to water or better feed have always required the ability to cover considerable distances in a short time.

Osborn (1910, p. 88) ncted that certain Eocene deposits were characterized by extinct mammals of a sort chiefly inhabiting a broken hilly and forested area, a country of plateaus, uplands, elevated basins, lakes and rivers. Other deposits of the same epoch contained the remains of types of mammals inhabiting open plains. These plains appear to have been traversed by broad, slow-moving rivers. Some of the plains areas were partly forested savannahs, with shallow lakes, and a tendency toward increased dryness. There is, indeed, evidence of distinctly arid periods in which considerable stretches of sandy flood plains became desert-like during the dry season, affording the opportunity for the evolution of mammals with slender or running types of limbs and feet.

Of special interest, perhaps, is Osborn's observation (1910, p. 93) that diminution of browsing mammals and increase of grazing species was one of the great features of Cenozoic evolution.

The evolution of the grasses, while relatively little-known, is of extraordinary significance. No family of plants possesses greater importance to mankind or, perhaps, to animals generally. Many important chapters in the story of animal and especially mammalian evolution are closely associated with them. There is little doubt that the important reactions of native plains animals, (grazing, trampling) on the grasses were of the same type in geologic times as at present; although at present, of course, there is this difference, that the original herds of grazers, doubtless in some sort of equilibrium with their food plants, have been largely replaced by the specially bred, vigorously selected, artificially cared for domestic livestock. In many places competition for grass has resulted in extraordinarily severe, unaccustomed, and prolonged pressure on the vegetation (probably unlike anything in geologic times) with serious results in depletion of the plants and erosion of the soil.

Seemingly the rise of the grasses is associated with the widespread extinction of certain mammalian types that took place at the end of Oligocene. This epoch witnessed a world-wide diminution of the larger types of browsing animals, creatures with short-crowned teeth and heavy limbs and feet. At this time the anthracotheres, anoplotheres, lophiodonts, xiphidonts and a number of other groups, disappeared or became much reduced in numbers and importance. At the same time there was an increase of grazing animals, with light limbs and long-crowned teeth, additional evidence of increasing aridity.

Survival appears to have been very closely related indeed to the structure of feet and teeth. Osborn (1910, p. 238) refers with approval to Kowalevsky's theory that " . . . mechanically defective feet were incapable of acquiring the elongation in the cursorial type which saved the lives of the artiodactyls with adaptively formed front feet. The short-crowned teeth could not survive the change of vegetation from the softer herbage of Eocene times to the harder grasses of late Oligocene and Miocene times."

Apparently the grasses continued to increase in upper Miocene (Osborn, 1910, p. 283), forming the chief food of horses and ruminants. The characters of the teeth and feet of these animals (1. c., p. 297) demonstrate the spread in America as well as in Europe of dry, grassy plains, droughts, arid seasons and long distances between water holes. The Pliocene, on the other hand (Osborn, 1910, p. 311) closed with a moister condition. Forest and river were interspersed with meadows favorable to browsing deer, as well as to the grazing animals, elephants, horses, and cattle, but studies by Dixon (1934) in California and by the writer and others in Texas have shown that under some present conditions at least, deer consume many weeds and much more grass than was formerly thought.

Without taking full account of the interrelationships involved between the grasses and the mammals, one would miss much of the picture. Seemingly it is clear that adequate explanation of historical geology depends on consideration of the biotic community.

In the Paleocene occurred a number of small herbiverous mammals which secured their food by gnawing and leaf-eating. (Among these were the Periptychidae (**Condylarthra**) and at least two families of the order Taeniodonta. Gidley believed that the aberrant diprotodont marsupial known as **Ptilodus** was fruit-eating, since its incisors are well-fitted for picking small fruits or berries. There is also an alternative view according to which the creature is regarded as a gnawer much like our present-day rodents.)

Almost as wide a range of interrelationships between mammals, plants, and environment is indicated in the teeth and skeletons of these Paleocene and Eocene mammals as among mammals of the present day.

Osborn points out that diprotodonty was developed in a number of Eocene mammals, including the Tillodonts, Taeniodonts and early Rodentia. The physical characters indicate plant-eating, gnawing, and leaf-cutting habits. Birds, too, are sufficiently represented to enable Osborn to conclude (1910, p. 151) that those from the Phosphorites of Quercy (Europe) are types fitted to great warm plains with groves of trees scattered over them. The variety of birds suggests a varied environment, very much the same, in its general relationships, as at present.

As might be expected, evidence from Pleistocene time becomes still more understandable and convincing. In the progression from Paleolithic to Neolithic (Osborn, 1910, p. 418) Nehring noted a transition from the pure arctic fauna of the so-called Lower Rodent Layer (in a grotto deposit at Schweizersbild near Schaffhausen) with the vole, hare, fox, reindeer and ptarmigan, to the Steppe fauna, with hamsters, pikas, and wild horses (forests absent) then to the Upper Rodent Layer, which indicates a steppe fauna intermingled with an increasing number of forest types such as squirrels, dormice, and the pine marten, and finally to the Forest fauna, with the squirrel, beaver, pine marten, stag, roe, wild boar and brown bear. There is consistent evidence that important changes in the plant part of the community were regularly reflected in the animals. It is of interest that the hairy mammoth (Osborn, 1910, p. 420) was part of the biotic community the plant portions of which included grasses, sedges, wild thyme, beans of oxytropis, as well as seeds of alpine poppy and crowfoot, all of which have been found in the mouth and stomach of a fossil mammoth.

There seems to be plenty of evidence that the relations and interdependence of plants and animals always were vitally important, although this point is seldom stressed in paleontological literature. On the contrary, running through the writings of some of the paleontologists one notes an uncritical assumption of absolutely independent development of plant and animal communities. Nothing that can be seen now, as modern biotic communities are examined, seems to justify this assumption. According to man's views at present plants and animals are pretty definitely interrelated. Animals, for example, are, and have always been, fundamentally dependent on plants for the starches and sugars which they cannot make from raw materials. It is not improbable that plants have always been more or less dependent on animals also. The flowering plants have certainly relied in a very important way on their pollinators. All plants may be somewhat dependent on animals, either for pollination, dissemination, number regulation, provision of CO_2 or of remains of their bodies, and assistance in the preparation of a suitable substratum. These fundamental interdependencies seemingly justify extension of the concept of the biocenose or biotic community to past times. In paleontology, as in modern ecology, attention has been too much concentrated on the structure and habits and distribution of individuals and individual species. The extremely important relationships, of individuals to each other, of species to each other, and especially the relationships of plants to animals and animals to plants, have not received the attention they deserve.

Perhaps it is not strange that relationships have not been stressed as they should in paleontology, where the records are fragmentary at best. Indeed, all too little attention has been paid them in the study of the plants and animals of the present day, where the records are relatively so much more adequate.

Clements (1916, p. 279) calls attention to the fact that while the study of fossil floras has steadily advanced our knowledge of geological floristics, especially in the last decade, the field of ancient vegetations remains completely unexplored. All that we have said up to date indicates that this is even more true of the field of ancient biotic communities. Osborn's keen interpretations afford a tantalizing hint of what we may expect when paleontology is put on a real ecologic and bio-ecological basis. It is not enough to study past vegetation or the animals of ancient times.

Life communities of the present day are wonderfully complex assemblages of plants and animals, interrelated throughout their entire distributional area and sphere in numerous important ways, ways so important, indeed, that adequate knowledge of the plants or the animals of the present is impossible without insight into their interrelations. One cannot possibly learn everything about plants by studying plants alone. He must give attention to the animals of the biotic community in which plants occur. Similarly with animals, one must know something about the plants with which they are inevitably interrelated.

Man likes to catalog, to pigeon-hole, to compartmentalize! Paper after paper is written in paleobotany, for example, with some of the most important data omitted. The plants are given careful attention, but some of their most important relationships, those to the animals, are left out. The losses to knowledge suffered by this method of specializing on the plants are doubtless quite substantial. For the most part paleozoological papers are just as bad. The animals alone are treated and their associated plants omitted. It is the exceptional writer who treats the plant-animal community. This is unfortunate, since the biotic community, made up of both plants and animals, is much closer to reality than its plant or animal portions taken separately.

SUMMARY

1. Improved knowledge of food and life habits of present-day animals, and of the interrelationships of modern plants, can be counted on to improve paleontological interpretations.

2. Plants and animals can be used as indicators of past environments in proportion as their present-day characteristics are known and as their known relations with their surroundings are distinct and definite. Clearly apparent is the need for careful study of the ecology of the present as a guide to that of the past. The variable conditions governing the preservation of fossil remains must also be taken carefully into account.

3. The all-too-prevalent custom of using data from plants alone or from animals alone in making paleontological interpretations is open to question. Complete and adequate explanation of the biological and physical events in historical geology can only be derived from a satisfactory understanding of the plant-animal communities of the past. In other words, biotic relationships must be taken account of in paleontology as in present-day biology. Evolution of plants, animals and environment has proceeded up through time as a great unitary process.

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THE CONSERVATION OF ARCHAEOLOGICAL RESOURCES IN TEXAS

T. N. Campbell and Alex D. Krieger
University of Texas

Archaeology, which is one of the sub-sciences in the broad science of anthropology, is concerned with the life of man in prehistoric times. One of its primary aims is to reconstruct the history of man during the long period which preceded the appearance of reliable written records. All intelligent people are interested in man's past, and it is the responsibility of the historian and the archaeologist to satisfy this intellectual curiosity. The historian relies on the written documents of the recent past, but the archaeologist must depend on information obtained from excavation in man's ancient dwelling places. These excavations provide the materials for scientific reports and popular books, and they also yield objects which illustrate the arts and crafts, daily life, and religion of man in the remote past. Museums display such objects and usually find that they attract great popular interest.

In Texas, archaeology is concerned with the life of the aboriginal inhabitants, the Indians, who were truly the first Texans. The complete history of Texas has not yet been written, and it cannot be written until archaeological research has revealed the events which happened before Europeans arrived on the scene in the sixteenth century. To the archaeologist it always seems odd to hear Texas history summarized "under six flags" during a period of some four hundred years, for he knows that Texas was under numerous "Indian flags" for thousands of years. The archaeologist is very much aware that the European is not the only variety of man who has successfully experimented with living in the Texas habitat.

It is not our primary purpose to show that the archaeological resources of this state should be protected in order that we may know more about prehistoric Texas. We take it for granted that all thinking citizens of Texas appreciate the educational and cultural value of a broad knowledge of man's life in the past, whether the scene be Europe, Asia, or America. But there is another aspect to archaeology which has not been sufficiently emphasized and which furnishes an additional reason why the archaeological resources of this state should be preserved and utilized properly. Archaeology can contribute information which has practical value for other sciences. To be specific, in this state archaeology has provided data which are useful to climatologists, geologists, geographers, agronomists, botanists, biologists, soil conservation and water engineers. That this infomation has not always been utilized is probably due to the mistaken impression that archaeology has nothing of a practical nature to offer.

Archaeological research in Texas and other nearby states has thrown considerable light on climatic fluctuations in prehistoric times, especially within the past few thousand years. It has recorded evidences of drought, erosion, floods, and heavy silting, all of which seem to be cyclic phenomena. Furthermore, archaeology has helped to date certain past climatic events. This knowledge will certainly have value in making future predictions. A few examples of contributions in this field may be cited.

The Great Plains, of which the Texas Panhandle is a part, is a great borderland lying between the humid east and the arid west. It is well known that such regions are subject to recurrent droughts of varying length and intensity. The white man, who has been farming this region during the past hundred years, has known severe droughts and crop failures. We all recall the widely publicized drought of 1934-1936, but there were also droughts in 1860, 1870-1873, 1889, 1893-1896, and 1917-1918.[1] In this hundred years only two long periods of deficient rainfall are known, 1893-1901 and 1929-1936,[2] each lasting about nine years. Fortunately for white farmers, the really severe droughts have been of relatively short duration and, except in the 1890's,[3] there has been no widespread depopulation of the Great Plains.

Recent investigations by climatologists and archaeologists suggest that the Indian farmers of prehistoric times in the Great Plains experienced droughts that were of much greater duration. The tree-ring records of Weakly[4] indicate exceptionally long periods of deficient rainfall in the past, as 1439-1454 (15 years), 1459-1468 (9 years), 1539-1564 (26 years), 1587-1605 (19 years). The archaeologist Wedel[5] has described numerous sites of the Upper Republican culture in Nebraska which are blanketed with layers of wind-laid materials, sometimes several feet thick. As a rule, the culture-bearing layers are associated with humic zones, which indicate the stabilized conditions which go with adequate rainfall. The Upper Republican people were

[1] Clements, 1938, pp. 4, 6; Clements and Chaney, 1936, pp. 37, 41, 43.

[2] Clements, 1938, p. 6.

[3] Clements and Chaney (1936, p. 43) state that approximately 500,000 people withdrew from the Great Plains during the great drought of 1893-1896.

[4] Quoted by Wedel, 1941, p. 25.

[5] Wedel, 1941, p. 18; 1947b, pp. 15-18.

Indian farmers who lived during the period 1200-1450 A. D.,[6] after which no trace of them has been found. It is believed that these corn-growing Indians were forced to abandon the Plains during the great droughts of the fifteenth century.

Krieger's[7] recent studies of the Antelope Creek culture of the Texas Panhandle confirm the evidence presented by Wedel. The Antelope Creek people farmed the Canadian River valley during the period of 1300-1450 A. D.,[8] after which they too disappear from the scene. Many Antelope Creek ruins were filled with wind-blown sand while the masonry walls were still standing, and it appears that they also were driven from the Plains during the great fifteenth century droughts.

This evidence raises a question which is of vital importance today. It suggests that within the larger, well-established climatic cycles of post-Pleistocene time there are also smaller cycles whose effects are too slight to leave notable marks on the earth. Yet these cycles seem to be of sufficient magnitude to affect human life favorably or adversely. If the Indians of the fifteenth century were forced to leave the Great Plains because of drought, it is reasonable to suppose that this situation could happen again. A future swing back to these conditions would have disastrous effects on modern Plains agriculture. The problem raised here seems to be important enough to justify an extensive cooperative research program involving climatologists, geologists, geographers, botanists, and archaeologists.

Geologists and water engineers have long been interested in rates of cutting and filling in Texas river valleys. In many instances it has been difficult to assign approximate ages to certain river terraces because adequate fossil evidence is lacking. The recent archaeological work of Kelley[9] in the Colorado River valley northwest of Austin has shown that archaeological materials are vertically distributed throughout of the 20- and 40-foot terraces. The human cultural remains in these terrace deposits have been dated by combined archaeological and geological techniques as falling within the period of 4,000 B. C. to 1,000 A. D. Here we have the beginning of quantitative data on rates of alluviation, archaeological materials having assumed the status of key fossils. Now that the problem is clearly defined, future excavations in Texas river terrace sites should yield more precise quantitative data.

There are other instances of the use of archaeological techniques to date recent geological events. On the Texas coast the archaeological materials which are buried in clay dunes are helping to assign dates to the period when these topographic features were formed. This throws light on recent shifting of the Gulf coast line, a matter of some importance in connection with the current controversy over the ownership of tidal oil lands. In the Finlay Mountains of western Texas archaeology has provided geologists with quantitative data on cliff

[6] Wedel, 1947a, pp. 150, 153-155; see also Krieger, 1947, p. 143.
[7] Krieger, 1946, pp. 38, 48-49, 71, 260.
[8] Krieger, ibid., pp. 47-49; 1947, p. 143.
[9] Kelley, 1947.

recession and slope stability.[10] And one geologist[11] has utilized archaeological evidence to show recent movement along faults of the Balcones system in central Texas. This evidence was used to support a theory which explains certain failures in locating pools of oil.

To conclude the argument concerning the practical value of archaeology, we can point to a number of possibilities which have not yet been fully developed. Archaeology can provide the geographers with information on former population density, early land utilization, and the effects of native life on the environment, i. e., burning the vegetative cover. Archaeology can furnish the agronomist with data on the field crops and agricultural techniques of former peoples. To the zoologist and botanist archaeology can offer data on earlier geographic distributions of animals and plants. The bones of various animals are found in camp sites, and dry caves in the west contain abundant plant remains. Archaeology can even contribute to medical history by providing human skeletal remains whose study can throw light on health and disease in former times.

If archaeology can make contributions of value to the other sciences, in addition to enriching our knowledge of man's past, it deserves the consideration of all scientifically-minded Texas citizens. The sources of archaeological information should be protected until all the essential data have been collected. The Federal Government has led the way by recognizing archaeological sites as constituting a national cultural and scientific resource. Seventeen monuments of archaeological interest have now been established. Through the cooperation of the National Park Service, the Bureau of Reclamation, the Corps of Engineers, and the Smithsonian Institution, archaeological work has been made a definite part of the great program for flood-control and irrigation.[12] Provisions have been made for the location and study of archaeological sites which will be damaged by constructional activity or inundated by the waters of numerous artificial lakes in the river valleys. Wherever possible, this work is being done in conjunction with state agencies.

But everything cannot be left to the Federal Government. Each state must have its own conservation program. Some states, among them Nebraska, Minnesota, and Oregon, have already taken progressive steps toward archaeological conservation. In these states well-informed officials in the highway and water engineer divisions of the state government instruct their field parties to notify competent archaeologists when sites are discovered in the course of their work. The same procedure should be developed in Texas. In building highways surface sites are frequently cross-sectioned, revealing the remains of prehistoric occupation, and important information is often lost when these sites are not reported. Likewise, surveying parties sent out by water engineers have opportunities to observe archaeological materials exposed in the banks of streams and canals. The value of such sites as sources of information on past climatic conditions has already been emphasized.

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[10] Campbell, Howard, Albritton, and Osburn, 1941.
[11] Bryan, 1935, 1936, pp. 1357, 1360-1366; Mason, 1936, 1937.
[12] Brew and others, 1947.

The Texas Academy of Science, as the official organization of Texas scientists, should play the leading role in the development of a program which aims at the conservation of the archaeological resources of this state. Here are some of the things which the Academy can do. (1) It can take steps to develop an informed public opinion concerning the value of preserving and reporting archaeological remains; (2) it can organize key public officials, engineers, and interested members of the lay public in such a way that newly discovered archaeological sites will be reported to the proper research agencies; (3) it can provide a means for the exchange of information between archaeologists and other scientists when this information is of value to both groups; (4) it can aid local museums in the development of displays which illustrate the life of prehistoric Texas peoples; and (5) it can publish occasional pamphlets of general interest designed to explain the interaction of man and environment in Texas, past and present.

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RUSSIA AND AMERICA—CONFLICTING IDEOLOGIES OR DIVERGENT CIVILIZATIONS?

Charles von Schwanitz
Formerly Vice Consul at American Embassy in Warsaw, Poland

On January 15, 1947, one day before the General Elections took place that determined the future of Poland, I left the city of Warsaw. On the day of my departure my Polish friend made an effort to impress on me for the last time what he considered to be my mission upon my return to the United States.

Before the war he had been a prominent faculty member of the Warsaw University, as well as a high ranking officer in the Polish General Staff. It would have been difficult to tell his eminent background from his appearance as he stood before me in the hotel lobby. He was stooped in premature age. He wore coarse alpinist's boots, the only pair of shoes left him from more prosperous times, and a baggy pair of loud sports trousers he had received from an American relief agency. But, despite the pathetic figure he now cut, there was no mistaking the earnestness of his entreaties.

"You have lived in Poland for almost two years now," he said earnestly to me in his precise English, "and you have had ample opportunity to appreciate the mood of Eastern Europe. Now you must tell your friends and acquaintances in America, not what is happening to individuals, but what is taking place in Europe as a whole. You must tell them the pattern of post-war developments that is so often lost sight of in the reporting of vivid, but disconnected, details." He paused to make a careful choice of words.

"America is a great country," he continued with sincerity, "but I do not believe that the American people understand what is going on in Europe today." He looked beyond me thoughtfully and added, "That is only natural. One must have lived in Europe and have absorbed its peculiar political climate, one must have been exposed to the mood of its peoples, in order to understand the significance of Europe's turmoils."

At the time I did not attach too much significance to my Polish friend's entreaties. I knew that, after all, a continuous stream of American observers had visited Eastern Europe, with as much access to current facts as I ever had. On the surface it seemed to me that there was little I could add to their pungent reports of Russia's encroachment on Western Europe.

But when I returned to the United States and came in touch again with American public opinion, I began to wonder whether there was not some truth in what my Polish acquaintance had said. Undoubtedly public opinion, during the almost two years of my absence, had undergone a drastic reverse. The people had gradually come to realize that Russia is not the peacable, if somewhat bumbling and adolescent, bear it was thought to be during wartimes. As I digested the editorials in the nation's press, I plainly saw that the public was only too well aware of the potential danger facing this country from Russia.

But, while I was reassured that the people perceive the threat, I wondered whether they understand the exact nature of that threat. I couldn't help feeling that the general apprehension concerning Russia, while only too well justified and long overdue, was based less on an objective appraisal than on an impulsive emotional reaction. The pendulum, so it seemed to me, had swung from extreme enthusiasm for Russia, our ally, to extreme antipathy towards Russia, the Communist dictatorship. Now it happens that at the moment both the objective appraisal of Russia's foreign policy and the public's emotional response toward it coincide in producing apprehension. But, I asked myself, would not public sentiment, when based largely on haphazard emotional appeal, in the future be subject to unpredictable fluctuation, resulting possibly in a second complete reversal of public opinion regarding Russia?

Now that was exactly the point my Polish friend had so earnestly tried to impress on me—that our foreign policy is in danger of depending on emotional vagaries of the moment rather than on a purposeful analysis of America's place in the historical pattern of our era.

What, then, is America's place?

The answer to that question depends primarily on an analysis of Russia's place in the historical pattern of our age, for undoubtedly America's historical destiny depends largely on that of Russia. And Russia's pattern of historical development, in turn, is best understood by investigating the causative factors of her foreign policy.

What is the dominant trend of Russian foreign policy? The answer to that question may surprise you. The dominant trend of Russian foreign policy is its consistency throughout recorded history. It appears to be a popular assumption that Russia's foreign policy in recent times has been unprincipled and ever-shifting. That assumption is incorrect. Russia's foreign policy has been, and continues to be, utterly amoral but it has always followed the same principles. The principles guilding present-day Russian foreign policy are essentially the same as those formulated by Czar John the Dread and his adviser Naszrokin several centuries ago.

What are those principles of Russian foreign policy? Like the foreign policy of every other country, Russian foreign policy is based primarily on direct and indirect defensive measures against possible aggression. It might be argued at this point that Russia nowadays has no foreign aggressors to fear, but Russia apparently is not in agreement with this reasoning. The basic psychological motivations for the ever-present Russian fear of aggression will be investigated at a later point in this article.

The Russian nation as a political entity is of comparatively recent origin. The countries along Russia's western border had achieved national unity when Russia herself was still without the semblance of centralized governmen or political unification. These bordering nations, and among them primarily the Swedes, the Poles and the Turks, were therefore much more powerful than the incipient Russian nation, comprising mainly a small area in the vicinity of Moscow. Russia was therefore constantly harassed, from the north, by the then turbulent

Swedes; from the west, by the arrogant Polish nobles; and from the south, by the Moslemites inhabiting present-day Turkey. In addition Russia suffered repeated devastating invasions from the east by Mongolian tribes. But since the impetus for the westward migration of the Mongolians in time disappeared and Russia was consequently able to extend its eastern frontiers to the Pacific, the eastern invasions do not play a significant role in the formulation of traditional Russian foreign policy.

The important consideration is that Russia was throughout her history, until comparatively recent times, constantly threatened from the general direction of the west. As an inescapable consequence Russia has developed a sensitive concern for its western frontiers. Out of this concern arose the traditional Russian policy of ingrained mistrust of its western neighbors that finds continued application today.

In logical implementation of this foreign policy, Russia has consistently sought to immunize or absorb politically the countries contiguous to its western border. In recent times Russia has again succeeded in either immunizing, absorbing or gaining political control over the countries which had unwillingly formed a part of the Czarist empire. The Baltic states, Poland, and the Balkan countries are examples in illustration. In continuation of its policy Russia is now striving to emasculate the last of its traditional foes, Turkey.

To the politically and historically unsophisticated observer it may prove bewildering that the current Communist government in Russia follows a policy identical to that pursued by the former Czarist government. Russia's Communist government is commonly believed to constitute the very antithesis of the preceding Czarist government and it has therefore frequently been assumed that the two governments' respective internal and external policies must be as different as night and day, or white and red, if you prefer. This assumption is incorrect; it constitutes a fundamental error with regard to our evaluation of the current Russian government's place in history.

A comparison of Stalin's government with the autocratic Czarist governments that wielded ruthless control during the height of early Russian expansion reveals startling similarity in all basic points of internal administration. Both forms of government constitute uncompromising autocracy; in both the people have no voice in the government and are subject to the will of their rulers, without recourse to law; both have as salient features a small class of privileged administrators; and in both forms of government the end justifies the means. The aparent dissimilarities are only surface illusions. For it is basically irrelevant whether the administrative aristocracy is reimbursed for its executive activities on behalf of the ruler with feudal grants of land and titles of nobility, or with grants of special privileges resulting in above- standard living conditions and with the honors a modern Communist autocracy bestows on its kommisars. The principle in both cases the same.

The mistaken idea that Stalin's autocracy and the ancient Czarist autocracies are dissimilar arises out of the confusion of the short-lived Lenin government with the present Stalin government. Virtually the only thing the Lenin and Stalin governments have in common is the label Communist. The bitter and deepseated feud between the so-called Trotzkyite communists and the Stalinist communists bears testimony to the unbridgeable chasm between the two ideologies sharing the definition of Communism.

When Lenin first raised the banner of the international proletariat's revolution in Russia, the ensuing early Communist government and the Czarist government it replaced were indeed as widely divergent from one another as is humanly conceivable. But Lenin's Marxist government was fundamentally an alien growth on Russian soil. Lenin's government represented a political ideology derived from and intended to supplant the conditions of liberal capitalism then prevalent in the highly industrialized western nations. Marxism was never planned as a blue-print for the rule of Russia, with its peculiar agricultural-bureaucratic traditions and its largely non-existent proletariat. The tenets of Marxism revolve around the uprooted proletariat of a highly-industrialized civilization. Russia had no industry worthy of mention.

Lenin's government did not come to power as the result of an evolutionary need. It did not fill an inherent need in the Russian pattern of development. On the contrary it rose to power as a result largely of a fortuitous chain of circumstances, based mainly on the anarchic conditions resulting from the ineptness of the Czarist administration prior to and during the first World War and on the determined lust for power of a small but tightly-knit group of revolutionaries.

By virtue of its alien origin and consequent unsuitability to the Russian political climate, Lenin's government was from the outset doomed to one of two courses. It could either continue to pursue its unsuited Marxist policies and eventually destroy itself, or it could in time gradually adapt itself to the historical needs of Russia. The Russian Communist government took the latter course.

The gradual reorientation of Russian internal and external government policy did not become fully apparent until Lenin's death. But with Stalin's assumption of power the shift of emphasis from internationalist Marxism to a form of nationalist communism could no longer be doubted. Almost all the propaganda concepts that had been so dear to the Marxist government vanished from the Russian scene. It was no longer considered good 'communism' to believe in free-love; or to extirpate all manifestation of religiousness; or to discourage family life. On the contrary, Stalin, like Hitler and Mussolini before him, now bestowed 'motherhood' medals upon prolific Russian housewives. Woman's participation in political life was discouraged. And the glories of Russian history were resurrected in sympathetic film portrayals of John the Dread and Peter the Great, who had formerly been the targets of Marxist calumny as oppressors of the 'proletariat'. The theme of class struggle was now largely confined to fanning the hatred for the 'Western capialist nations,' But the about-face that had taken place since Lenin's days was best typefied by the slogans under which Lenin and Stalin made their appeals to the masses. Lenin appealed to them in the name of the international proletariat. Stalin appeals to them in the name of Russia.

Indubitably Stalin has resumed the thread of autocratic nationalism that has run through the history of Russia since John the Great established the independence of his country by banishing the Mongolian invaders. Stalin reestablished the traditional Russian form of government, not as a result of subtle political theorization, but because his undeniable statesmanlike instincts told him that it was the only course open to strengthen Russia internally and externally.

Why have fervent nationalism and ruthless autocracy become traditional in Russian history? Like the morbid suspicion of its western neighbors which forms the motivation for Russia's foreign policy, the fervent nationalism and placid acceptance of autocracy have their origin in the formative period of the Russian national character.

The two salient factors that meet our eye when we view Russia's history are the frequent periods of its domination by foreign conquerors and the resultant isolation of the Russian people from our civilization. In particular this holds true of Russia's repeated and lengthy subjugations by Mongolian invaders, extending into the fifteenth century. During the bleak periods of foreign tyranny, the Russian peasant would migrate into the virgin woodlands, where he would find comparative freedom. As a result he would, however, be severed completely from the civilizing influences to which peasants in the contiguous areas of Poland, the Baltic states and the Balkans were exposed, even under the most trying conditions of serfdom.

As a consequence of his bitter experiences with foreign invaders from the east and the west and his attendant isolation from our civilization, the Russian came to nourish a deep mistrust of all things foreign. He has retained this deeply conditioned mistrust to this day, stubbornly clinging to it in the face of even the friendliest overtures. We have been inclined to underestimate the tenacious stubbornness of the Russian's ingrained isolationism. This national characteristic was acquired during a period of many centuries and it appears doubtful that it can be discarded from one day to another.

The Russian has acquired a second national characteristic as an indirect result of his country's repeated invasions and conquests. That is his placid acceptance of an autocratic form of government.

An incipient nation in its early formative period is necessarily weak and disorganized. In order successfully to oppose foreign encroachments on its territory it must utilize every bit of its meagre resources. It has no well-trained administrative machinery to organize the undisciplined inhabitants into a potent weapon of defense. The inevitable result of these conditions is that the young state will be forced to take recourse to coercion in order to place the country on a wartime footing. A primitive autocracy is thus created. If the country is in constant danger of foreign invasion, the autocracy will be perpetuated even during the infrequent periods of peace.

An autocratic form of government was thus, under the existing primitive conditions, the only alternative to the even more odious tyranny of foreign invaders. As set forth by outstanding historians on Russia, the people in time came to accept the autocratic form of government instinctively as a guarantee against foreign domination. The early formative periods of almost all peoples subjected to foreign conquest appear to have run a similar course.

The national traits of morbid suspicion of all things foreign and of firm reliance on an autocratic government for protection against the unknown world beyond the country's borders are the salient characteristics of an immature civilization. They are representative of a primitive phase in a people's historical development.

We have in the past slipped into the careless habit of regarding Russia as just another nation, pigeonholing it with such countries as England, France, Poland or any other European country. That is a fundamental and far-reaching error. England, France and Poland are individual nations, but they are all components of one and the same civilization. Russia represents an incipient civilizational entity of its own, entirely separate from and unrelated to the civilization of the West or, for that matter, different from any established civilization of the East, North or South.

During their almost uninterrupted isolation from the civilization of the West, the Russian people were thrown upon their own spiritual resources and as a result developed a civilizational and cultural outlook strictly their own. Their civilizational orientation they found in the 'mire', or primitive village socialism, which has carried over into many aspects of the current Russian government's administrative policies. Their cultural outlook they derived largely from the Orthodox faith propagated in Russia by Byzantine missionaries, but adapted to the inherent mysticism of the Russian.

Thus the Russians' fervent sense of nationalism, their vaguely defined but strongly felt autocratic-socialistic tendencies, and their deeply-felt mysticism enriched by Byzantine influence resulted in the gradual unfolding of a new civilization, a civilization that is as yet rough-hewn and loosely defined, but which has a definite and unwavering orientation. And this orientation is diametrically opposed to that of western civilization.

The apparently unbridgeable chasm between the two civilizations, in their present disparate stages of development, is perhaps best illustrated by the failure of the westernized Russian aristocracy to graft the alien western civilization on the Russian people during the nineteenth century. Czarist aristocracy, wholeheartedly enamored of the advantages of western civilization, gradually lost contact with the powerful civilizational-cultural fermentation taking place in the rank and file of the Russian people. That factor more than any other was the cause of the Czarist aristocracy's downfall. The Russian people stubbornly refused to be swayed from the path of their instinctive choice, dimly seen but strongly felt.

This inevitable disparity in outlook between the incipient Russian and our own highly polished civilization is the key to the understanding of the apparent complexities of the current world situation. The increasingly apparent incompatibility of Russia and the western powers is not so much the result of ill will or stupidity on one side or the other, as it is a symptom of discrepancy in historical development. Russia is in an earlier phase of civilizational growth than the western nations are. The Russian axioms of political reasoning are vastly different from our own. We may both employ the same simple processes of ratiocination, but by virtue of our irreconcilably different premises we will always reach incompatible conclusions. And each will self-righteously hold the other to be maliciously wrong.

Russia's national independence is of relatively recent origin. The cultural and civilizational progress of the Russian people was retarded for many centuries by foreign intervention of one kind of another. The Russian people are now laboriously crawling up the rungs of a ladder that was scaled by our leading spirits many centuries ago. It is true that the Russians now have the advantage of using the technological improvements forged by western civilization. But the spiritual growth of an embryonic civilization cannot be hastened by mechanical means. If anything such means, if abused, will retard its growth. The broadening of a nation's civilizational outlook can no more be hastened, than a child can be made to mature into a man overnight.

And that is the point my Polish friend had tried to make. The struggle now taking place behind the scenes is not the clash of international Communism with the forces of progressive democracy. It is not a struggle between political abstractions. It is the inevitable fight for dominance between the aggressively developing civilization of Russia and the established civilization of the West. It would be idle to speculate on possible parallels between our era and the days of the Roman empire's struggle with the Barbarians, our ancestors. But it is essential that we essay objectively our position in relation to Russia.

Our position should not be dependent on what we interpret today as Russia's ill will and on what we may tomorrow interpret as Russian good will. Moralistic judgements of approval or disapproval should be confined to the workings of a well-integrated society that has accepted and generally abides by a common denominator of morality. But the forces of history in their deterministic workings are as amoral as all other phenomena of nature.

And the spontaneous growth of Russia is as much a phenomenon of natural forces as is the young oak that pierces the rotting foundations of a neglected house. Russia is no more capable of moralistic analysis of its impulsive expansionism than the oak is. That is what my Polish friend wanted me to tell America.

American foreign policy should be predicated on careful analysis of the long-range pattern of Russian historical development. Instead of indulging in continued wishful thinking about Russian foreign policy of tomorrow and hoping that Russia will suddenly reverse herself, we should take for granted her continued adherence to the historical pattern and plan accordingly. Instead of waiting in each and every instance until Russia has taken the offensive and then sending futile and unenforced notes of protest, we should plot Russia's probable future moves on a farsighted basis of historical perspective and seek to forestall them. If our foreign policy had been charted along these lines in the past, rather than having been subject to the whims of amateurs and the selfish machinations of pressure groups, Poland would still be a free and independent nation.

THE FOREST REGIONS OF TEXAS

S. L. Frost
Executive Director
American Forestry Association

Dr. William L. Bray, one of Texas' most outstanding botanists, said after a survey of the forests of the state, "Texas is the battle ground for supremacy of the plant races."

In our language today, we might call Texas the forest melting pot of the Nation. For within the boundaries of this vast state we find four of the six main tree regions of the United States. The southern pine forests have swept in from the East. The central hardwood forests make up our post oak belt. Forest growth typical of the Rocky mountain region is found in some of our mountains in West Texas. Trees that thrive in arid climates are found in South Texas.

Texas also has regions of trees, such as the mesquite, cedar brakes, oak shinneries and live oak which, though we cannot claim them entirely as our own, are of such extent as to be recognized as separate types.

TEXAS ADAPTED TYPES

Fighting the heat, the drought, the winds and adapting themselves to new kinds of soils, many of the trees which are common to other sections of the country have through the ages developed into well established Texas' varieties of their more kindly treated ancestors. Mountain cedar, Mexican walnut, mountain live oak, Texas redbud, Texas buckeye, all common to the Edwards Plateau region, are close kin to red cedar, black walnut, live oak, redbud, and buckeye of moister regions.

This battle of adaptation has given Texas almost 800 kinds of woody plants growing from the soil on 76 million acres. No state in the Nation can claim as large an area of tree growth.

Of all the factors that determine the pattern of the state's tree growth, moisture plays the most important part. This may be the moisture derived from rainfall. Or it may be the amount of moisture which the soil holds. In the eastern part of the state with almost a 50 inch annual rainfall, the pines and hardwoods grow tall. In West Texas, in a 15 inch annual rainfall area, some oaks are not over knee high. They form the oak shinneries, the pygmy forests of the state.

Geological formations, soil quality and other features of nature also determine the pattern of tree growth in Texas.

SURVEY NEEDED

Never has an adequate survey been made of Texas woodland acres. The 76 million acres set down as tree growth is not backed by accurate facts in many cases. Money and personnel have never been made available in the quantities needed to chart the tree growth of the state.

The East Texas pine and hardwood belt, where commercial timber products have been cut more more than a century, has been well mapped and surveyed. This region is supplying Texas and other parts of the nation with crops of lumber, paper and many other products. Scientific forestry is being practiced on a fourth of the 11 million acres in this belt. The trees in this region are considered a crop of the soil. With good farming methods, the state can always have tree crops from East Texas.

But from the west edge of the pineywoods there stretches an area of 65 million acres of trees that have largely defied commercial use. These are the post oak, cedar brakes, cross timbers and other regions. Great expanses of them are cleared for ranches and farms. But some of the regions like mesquite are spreading.

As we go from east to west the quality of these countless acres of trees gets worse. This more than any one factor explains why they are not used to any extent for lumber. Some of them like mesquite and ebony have as beautiful a grain as any trees in America. They are used to make woodenware novelties. This use has not been developed in the proportions it might. Texas could support lots more small wood manufacturing plants to take advantage of its supply of beautifully textured trees.

A CHALLENGE TO RESEARCH

With the advancements in wood utilization for chemical products, Texas forests present a challenge to the research man. People may raise a questioning eye at ever making anything good out of a lot of poorly-formed scrub trees in the state. But as long as rubber of commercial quality can be squeezed out of a lowly two foot shrub like guayule, there is hope for the ten or twenty foot tree that contains millions of cells of cellulose.

When Texas will get down to the business of really using its low-grade forests is any man's guess. There are still a lot of questions to find out the answers to. It is going to take some long and serious research.

As the Nation turns more and more to the use and dependence on crops and fibres of the soil, we will turn to our forests—Nature's greatest factory of cellulose. From trees we can get the things that will clothe, shelter and help feed us.

FACTUAL INFORMATION ON TEXAS FOREST REGIONS

(Timber volumes for East Texas and post oak by U. S. Forest Service. Other timber volumes are estimates by Texas Forest Service. Soil data furnished by Edwin H. Templin, Texas Agricultural Experiment Station.)

EAST TEXAS PINE AND HARDWOODS

Area in trees—11,000,000 acres—in 36 counties.

Principal soils—The uplands, comprising 87% of the area, are of lightly-colored leached acid more or less sandy soils of low natural fertility. In the absence of fertilization, tree crops, which root deeply, are better able to thrive on these soils of low fertility than are annual crops and grasses. The main groups of soils and the approximate percentages of the total East Texas Pine and Hardwoods Area they occupy are as follows: (1) 33% of well drained sandy loams and loamy sands with friable permeable subsoils (mainly Bowie, Ruston and Kirvin soils), (2) 14% of similar but slowly drained soils, mainly in the Flatwoods of southeastern Texas and originally occupied by longleaf pine (mainly Caddo, Segno, and Angelina soils), (3) 23% of well-drained sandy loam and loams with clay subsoils (mainly Boswell, Sawyer, and Susquehanna soils), (4) 7% of loose deep sands (mainly Lakeland soils), (5) 6% of gray wet loams with heavy clay subsoils, comprising pine-oak and postoak flats, mainly in Red River and adjoining counties (Lufkin soils), (6) 4% of redlands originally forested mainly with red oak and sweet gum (mainly Nacogdoches soils), and (7) 13% of bottomlands (mainly Bibb, Iuka, Ocklockonee, Trinity and Kaufman soils).

Average rainfall—45-50 inches.

Estimated standing timber volume—67,300,000 cords softwoods; 46,700,000 cords hardwoods. (Includes timber 5 inches and over in diameter breast high.)

Major species—Longleaf, shortleaf, loblolly pines; red, tupelo, and black gum, white and black oaks; cypress, cedar, white ash, magnolia, elm, cottonwood, hickory, beech, sycamore, maple, and walnut.

Uses—Lumber, pulpwood, baskets, ties, poles, fence posts, fuelwood, furniture, handles, boxes and toys.

POST OAK BELT

Area in trees—5,000,000 acres—in 55 counties.

Principal soils—Similar to those of the East Texas pine and hardwoods area, but somewhat less acid and having a much larger proportion of inter-mingled prairies and much less of the sand soils with friable subsoils. The uplands are mainly Boswell, Tabor, Lufkin, Susquehanna, Kirvin, and Lakeland soils; the bottomlands, which comprise about 15% of the area, are mostly clays and clay loams of the Trinity, Catalpa, and Kaufman series.

Average rainfall—35-45 inches.

Estimated standing timber volume—32,700,000 cords hardwood; 477,000 cords pine; 180,000 cords cedar.

Major species—Post oak, hackberry, elm, mesquite, pecan, live oak, ash, hickory, cedar. Loblolly pine in Fayette and Bastrop Counties.

Uses—Fuelwood, fence posts, ties, bridge decking and some lumber.

EAST AND WEST CROSS TIMBERS

Area in trees—5,000,000 acres—in 31 counties.

Principal soils—Mostly of moderately sandy soils of low fertility with subsoils of reddish clay (Windthorst soils) similar to group 3 of the East Texas Pine and Hardwoods Area but only slightly acid, less leached, and of slightly higher fertility. The area includes many intermixed prairies (largely of Kirkland and Zaneis soils where on shale, and of Tarrant and Denton where on limestone), considerable forested shallow soil over sandstone (Darnell soils), some loose sands (Nimrod soils), and a minor proportion of sandy loams with friable subsoils (Stephenville soils).

Average rainfall—25-35 inches.

Estimated volume—25,000,000 cords.

Major species—Post oak, black jack oak, live oak, shin oak, western red oak, mesquite, elm, hackberry, cedar and pecan.

Uses—Fuelwood and fence posts.

CEDAR BRAKES

Area in trees—5,000,000 acres in 53 counties.

Principal soils—The cedar brakes proper are almost entirely of stony or chalky nonarable soils of the Brackett, Ector and Potter series, which are shallow over limestone or caliche. On the darker, shallow, stony Tarrant soils of the Grand Prairie and Edwards Plateau, the principal woody species are Spanish oak, live oak, and shin oak. Associated deeper soils, largely of the Denton, San Saba, and Valera series, are dark crumbly clays and largely in cultivation but originally were grassland with scattered live oak trees.

Average rainfall—20-35 inches.

Estimated volume—30,000,000 cords.

Major species—Mountain cedar, redberry, juniper, live oak, shin oak, western red oak, catsclaw, sumac, buckthorn, elm, hackberry, ash, cypress, pecan and mesquite.

Uses—Fence posts, fuelwood, cabinet lumber, novelties and cedar oil products.

MESQUITE

Area in trees—50,000,000 acres—in 113 counties.

Principal soils—In the Rolling Plains of west-central and northwest-central Texas, mesquite is most abundant on the deeper heavier soils, mostly of the Abilene, Foard, and Tillman series. In the Rio Grande Plain, south of San Antonio, the soils are mostly sandy loams to clay loams. They are neutral and mostly limy, moderately to highly fertile. The principal soils series are Webb, Duval, Brennan, Victoria, Orelia, and Goliad. In extensive areas of loose sand (Nueces soils) in Kenedy and adjoining counties, the principal woody vegetation is mesquite and live oak.

Average rainfall—15-30 inches.

Estimated standing timber volume—100,000,000 cords.

Major species—Mesquite, shin oak and catsclaw in Rolling Plains region. Mesquite, ebony, huisache, agrito, catsclaw, live oak, retama and many other shrubby trees in the Rio Grande Plain of southern Texas. Elm, ash, hackberry, and pecan along streams.

Uses—Fuelwood and fence posts, limited amount used for furniture and woodenware novelties.

MOUNTAIN FORESTS

Area in trees—No estimate available—in 12 counties.

Principal soils—Stony, nonarable, very shallow but moderately dark and moderately fertile soils largely on igneous rocks (Brewster series) and limestone.

Average rainfall—10-15 inches.

Estimated standing timber volume—No estimate available.

Major species—Pinon pine, western yellow pine, Douglas fir, juniper, oaks, ash, Spanish walnut and mesquite.

Uses—Fuelwood mainly.

ON THE NEED FOR RESEARCH ON, AND THE CORRELATION OF, VARYING PHASES OF BIOLOGY, GEOLOGY, ZOOLOGY, BOTANY, ORNITHOLOGY AND THE RELATED SCIENCES IN TEXAS

J. L. Baughman
Chief Marine Biologist
Texas Game, Fish and Oyster Commission

Within the past six years I have been actively engaged in the preparation of an annotated bibliography on the fishes and fisheries of Texas. This is now completed in as far as such a work can be. During all this period one thought was recurrently brought to my attention.

Recently I have had occasion to meet with this same thought in connection with a number of other facets of marine biology and Texas natural history.

In going through the literature to accumulate such a bibliography I have, time and again, stumbled upon papers, sometimes in most obscure publications, dealing with some phase of Texas natural history other than that in which I was interested at the moment and, ordinarily, I have made a card on this. Thus over a period of time I have accumulated possibly 4 or 5 thousand titles on most of the phyla of the animal kingdom which occur in Texas. However, I have been repeatedly surprised upon talking with people interested in other phases than my own, to find that they were unfamiliar with many of the publications in their own particular line which contained Texas material, and which I had in my card index.

On second thought I could readily see why this might be so. The publications are many and diverse and they are often not available to the student. At other times they occur in periodicals where one would not normally expect to find them and, as a result, are overlooked. Few ornithologists, for instance, would suspect that there are some very important Texan bird papers in the old bulletins of U. S. Geological Survey. Not many naturalists would look in the records of the War Department or of the Coast and Geodetic Survey for observations on the bird and mammalian life of early Texas, yet they are there.

The mass of material available is surprising, not only in the earlier publications but also in the later ones. Scientists, being what they are, publish wherever they can, in the journals most familiar to them, and very often another scientist to whom this publication is valuable may be entirely unfamiliar with it.

As all of us know, the sciences are interrelated as closely as the interwoven threads in a piece of cloth, and very often the answer that one man has worked out will cast entirely new light on another's problem in an entirely different line.

There has been, as I have said, an immense amount of work done over a period of time. For instance, companies like the Humble and Dow Chemical, agencies like the U. S. Engineers and the Coast and Geodetic Survey, schools like A & M and Texas, and independent investigators, all have conducted and are conducting research on physical and biological problems peculiar to Texas, but because of the lack of a correlating agency much of this is not available to other investigators, who may not have time to go through the vast and voluminous literature that is published today.

It seems to me, then, that in no other single way could the cause of science be advanced as much in Texas as by the establishment of a correlating agency. To obtain the best results, such an agency would be in touch with all the research laboratories in the State of Texas, and they should forward to the agency all material published by anyone in their organization, on any work that they are doing, or have done, with reference to problems affecting Texas. Moreover, it seems to me that it would be a very desirable thing for such an agency to publish, from time to time, a series of abstracts of new work, combined with reviews or republication of work that had been previously done but that was not generally known. It makes little difference what such a publication should be called, the matter of prime consideration is its content. Presumably, this should include any and all papers on the natural sciences in Texas, and should endeavor, above all, to present those early, or otherwise obscure publications, not generally available.

To give an example of what this would mean, I may cite a recent talk which I made in Houston, about a subject on which I am not particularly well informed, namely, marine fouling. During the preparation for this talk it was necessary for me to check into this very thoroughly, and I was surprised to learn that a rather thorough investigation of this had been made along the Texas coast by scientists working with the National Research Council some 25 years ago; so were other people interested in the problem when I mentioned it to them. Further investigation disclosed the fact that a number of the railroads, chemical companies and industrial and wood preserving concerns situated in the state had made and were still making investigations along these lines. I am sure that many of the investigations were duplicates of each other, and I am equally sure that had all these investigators had available to them the results of any previous investigations, their work would probably have progressed more quickly and there would have been much less duplication of effort.

To take another case in point, recently a well known geologist came into the office to meet an equally well known mammalogist. The geologist had discovered that there was a correlation between certain geological formations and a certain type of mammalian fauna but, because he was not familiar with the mammalian literature on the subject and because there was no correlating agency to which he might turn, it was necessary for him to depend on the mammalogist to obtain the references which he needed.

To give an example from still another field, let us consider the case of the periodic recrudescence of a demand for passes through the barrier islands of our coast. The man in the street thinks a great abundance of fish can be produced in our bays by the construction of passes between them and the Gulf. The argument is periodically advanced with great vehemence and the general consensus is that all that is necessary is to take a dredge and cut a pass directly across the islands.

This should not take much money, according to its proponents, and it should be a simple matter to keep the passes open. Unfortunately, this is not so. A study of the geology of the coast line and of the mechanics of the formation of offshore bars along the Texas coast will give a good and valid reason why such action cannot be successful. Here again, unless the marine biologist chances up on the geological papers dealing with this, he has no way of finding them or of knowing that they are in existence.

A fourth example may be given, namely, the effect of the farmer and ranchman on the oyster reefs and the shrimp and fish populations. The enormous load of silt discharged by our Texas streams is a very significant factor in the marine ecology of our bays, yet information on this is not ordinaraily available to the worker in marine problems, through those publications ordinarily used by him.

Such a correlating agency as I have outlined above would be of inestimable value in those cases I have given, and I am sure that each of you can think of many instances in his own particular field, whereby he would have benefited by the knowledge of others being made readily available.

So complex are the problems of nature that no one worker alone can begin to comprehend them. I am reminded in this connection of the story of the three blind men who went to see an elephant. One of them, coming against its side, said, "Now I very plainly perceive that an elephant is like a wall." The second, grasping the ungainly beast by the tail, was equally certain that the elephant closely resembled a rope, and the third, grasping the long and sinuous trunk, was thoroughly convinced that an elephant was like a snake. All three of them were right as far as they went, yet because of the lack of a catalyst by which their knowledge could be combined, were wrong as wrong could be. Many of us are in the same position.

THE SCIENTIFIC METHOD IN THE SOCIAL FIELD

E. E. Rosaire
Consulting Geophysicist
Dallas, Texas

THE SCIENTIFIC METHOD

The scientific method is a rather unusual discipline. Those who practise it take no preliminary oath or final vows, are not subject to a specified code of law or ethics, and recognize no associated hierarchy or enforcement body. The scientific method is no esoteric ritual disclosed to communicants alone, and it does not make its practitioners any more or any less human.

While the pracitising scientist submits voluntarily to the judgment of his peers, he reserves the right of challenge and appeal, or he may refuse to accept that judgment, relying upon his own efforts, or those of others, to prove his case. The operation of the scientific method is hardly strength through joy or peace with honor, for, while no wars have been provoked thereby, controversy, sometimes bitter, often has raged, wherein reputations have been won, and lost. It flowers in its self evolved atmosphere of collective, learned skepticism, in which the ultimate and only arbiter is demonstrable, reproducible, and factual evidence. Recalling only too vividly the trials and tribulations of their predecessors in a non-scientific world, its practitioners are allergic to too close a relationship with established, non-scientific authority. Thus, many natural scientists, while acknowledging the over-riding importance of immediate necessity, have expressed concern at the secrecy imposed today, for reasons of national security, on some phases of fundamental research. They fear that its undue continuation may lead to what appears to be taking place today in Russian genetics, the development of a self-sealing, dogma-ridden system, antithetical to the scientific method, and so to scientific progress. At the same time, its practitioners hold that there is nothing sacred or sacrosanct about the scientific method, any more than there is about bread and butter, for the scientific method has proved to be only the staff of life for the natural sciences.

The scientific method appears to be no rigidly fixed formula, for it is applicable to the experimental sciences, like physics and chemistry, and also to geology, for which laboratory techniques are, in general, hardly applicable.

Essentially the scientific method is the application of two steps to the acquisition of knowledge. The first step includes the observation and classification of factual data, and the formulation of an hypothesis to introduce some measure of previously unrecognized order into those data. This hypothesis must be of such a nature that it can be tested for validity in the light of new or previously unconsidered data, preferably by an experimental check. If the hypothesis fails to account for the previously unconsidered data, it is rejected, or modified so as to account for the increased body of factual information. Only when a hypothesis, whether in its original or modified form, continues to account for new factual data as well as for those on which it was formulated, is it raised to the status of a theory; and only following regular confirmation by much more extensive and rigorous testing, is it generally accepted as a natural law. Even such premier status, however, obtains only during perfect behavior, for valid, contrary evidence, no matter how delayed its appearance in court, automatically opens the case for review.

Although the foregoing description may suggest a certain rigidity, in practice the scientific method is characterized by a fair amount of flexibility. Thus, the initial rung of observation may be the work of one investigator, or more, operating singly, or together, at the same, or different times. The second rung of classification may be achieved by the same or other investigators, working with the original observations, or adding their own to the accumulation. The third rung, completing the first step, of formulating a hypothesis, may be done by a third individual or group. The geologists, at this point, prefer to formulate multiple hypotheses, so as to widen the operating range of the second step, that of developing and applying the critical test data. As a rule, this two-step sequence is distributed over a period of years, and may involve the work of different investigators over an appreciable period of time. Often, many of these investigators may have worked quite in ignorance of the use to which their endeavors finally were put.

Again, the hypothesis advanced may be continued in the form of reserved acceptance even if contrary evidence develops. If the possibility of its confirmation is significantly high, it may remain in force as a working hypothesis, accepted with admitted reservations because of the limited state of our present knowledge. Thus, our current procedure of oil-finding represents imperfect procedure, the use of a working hypothesis which is considered economically justified under existing conditions, even if the chance of failure is several times the chance of success. In practice, an obviously imperfect hypothesis often remains under serious consideration, in a state of "half a loaf is better than no bread," until another is advanced which stands up better under trial by experimental test. Such a "better" hypothesis, however, usually is accepted generally only after a period of discussion and debate. As mentioned earlier, the scientific method has left its practitioners still quite human, in that, even in the face of incontrovertible evidence, many natural scientists exhibit what is called, for society · at large, "cultural lag." Even we natural scientists, presumably indoctrinated with the scientific method, remain much more "human" than "scientific."

GENERAL ACHIEVEMENTS OF NATURAL SCIENCE

The operation of the scientific method has led to one of the most outstanding developments of our time, if not just that, the achievement of science in bringing order out of a material portion of Nature's disorder. This, now progressing at a rate approximating the exponential, appears to have brought about that ever-denied-something-new-under-the sun, the creation of trans-uranic elements.

The scientific achievements have had desirable effects. Outstanding among them are a marked increase in the average span of life, cures of age-old diseases, and effective measures against civilization-old epidemics. Communications now are practically world-wide, and take place, point to point, with the speed of light. Travel has gone far beyond the horse and foot locomotion of two centuries ago. As for energy resources, wood, the age-old stand-by, now is becoming even more valuable because of its recognition as a "universalrohstoff"; and we are not unduly concerned about an apparent warehouse stock of fifteen years for our prize fuel, petroleum, for atomic power appears to be just around the corner, or at least not more than half a generation away.

However, there are those who question the net worth of these scientific achievements, pointing out that they have had undesirable effects. Bigger and more devastating wars are here, with the next promising not only more of the same, but also innovations, the mere suggestion of which cause phobias which verge on panic. Today, we speak of the teeming millions of Asia, but tomorrow we may well speak of their billions, who, certainly will request their lebensraum. There are not a few today who have reached the conclusion that the world of old was a near Utopia compared with today's Inferno, and who would, if they could, willingly turn back the clock to pre-horse-and-buggy-days. Such dreamers in the past, worshippers of that which has gone with the wind, shut their eyes to the realities of those days, of a much smaller world which had horrors of its own proportionate to whatever science promises for World War III. It was only yesterday, relatively speaking, that Yellow Jack raged in New Orleans. In the fourteenth century, the mortality rate of the Black Death is estimated to have been from one half to two thirds in Europe, and even higher in England. To Ghengiz Khan and Tamerlane, city-wide devastation was a common practice, and the Spaniards did not need our modern technology to wipe out the Incan and Mayan civilizations. If there ever were the "good, old days," the living then also prayed "From battle, murder, and sudden death, Good Lord deliver us!", and they had a much lower life expectancy.

In offering comfort to the despondent, I do not mean to encourage the complacent. I agree that many of these contributions of science appear to be not unmixed blessings. The radio is a major achievement in communications, bringing city within speaking distance of city, transgressing national and continental boundaries, yet, while it brings great music within hearing range of all, it also brings the soap opera to housewives, suggestive crime stories to adolescents, and subversive propaganda to guileless citizens. As we raise the standard of living, the birth rate falls, and the divorce rate increases. As the incidence rate of infectious diseases drops, those for the degenerative diseases and mental ills appear to rise. And Mars, today, is panoplied in unthinkable horrible accouterments. It seems as if we cannot eat our scientific cake and have it too.

As a matter of observation, however, this phenomenon of a mixed blessing is not a foundling left on civilization's doorstep by science alone. No matter how innocent and how charitable their fundamental tenets, many if not most religions too often pass through a phase wherein those tenets have been interpreted in a somewhat peculiar fashion. The creed of the gentle Christ no doubt appeared as a very questionable blessing to the victims of the Inquisition, to the Aztecs and the Incas, and to the black slaves of our own South. It seems as if Opportunity, knocking at Man's door, too often is characterized by a dual personality.

THE NON-SCIENTIFIC METHOD

With respect to the secular learned world, Conant has proposed an operational test whereby science can be distinguished as accumulative knowledge, in that "when it can be said that earlier writers or practitioners, if brought to life today, would recognize the superior position of their successors, then we can speak of accumulative knowledge."

I submit that the present identification of progress in natural science as accumulative knowledge follows from the operation there of the scientific method, whereas those other fields of learned effort (in which logical processes also are used) cannot be classified as accumulative knowledge because of reliance therein upon what might be called the non-scientific method. This much more venerable technique parallels but is basically different from the scientific method described earlier.

In one form of the non-scientific method, speculation is substituted for the initial rung of observation, and the hypothesis formulated to complete the first step is not one which can be subjected to test by reasonably acquirable, factual data. In theology, the operation of this non-scientific method can be seen in the once widely accepted Biblical Theory of Creation, and the argument that man had fewer ribs than woman (had not one of his been used to make her?). In politics, its operation is evident in the concept of the Divine Right of Kings, universally accepted, even today, as the basis of one of the stop rules of chess.

In another form of the non-scientific method, while the preliminary rungs of observation and classification can be recognized, the hypothesis advanced still is not subject to test by attainable, factual evidence. This form of the non-scientific method appears to be that applied in ethics, a so-called normative science, "not primarily occupied with the character of human conduct but with its ideal, not so much with what human conduct is, but what it ought to be." (Encyc. Britannica).

To the man of ethics, the scientific curriculum must be a tantalizing disappointment, for consider how the scientist constantly evades and dodges the ethical issue in the very things which he studies and practises.

Quite early in his course, the chemist or physicist-to-be spends a fair amount of his time on the Ideal Gas, the gas with properties as they should be. (Immediately thereafter, however, he is warned to stay shy of that ideal, to leave it alone, to apply more and more corrections on its behavior, until, by the time he has graduated, he goes directly to the Handbook of Physical Properties for each particular case.) Later, he is confronted with the Ideal Machine (and then warned against going too far into the theory involved, that of Perpetual Motion). Such procedure is poor conditioning for a future ethical scientist.

Rather, his studies should be directed at the design of bridges to be built of ethical materials which would have zero weight per unit length. Since such a bridge could carry an infinite load, the designer could concentrate entirely on lines and form, rather than on such a mundane consideration as riveting versus welding. Consider the possibilities in rural electrification resulting from the use of ethical materials for electrical transmission lines, for, in addition to zero weight per unit cross section, they also would have zero resistance to electricity and air currents, and, of course, zero cost per unit length. As for transportation, rocket travel would be materially simplified by the use of ethical fuels, with zero specific gravity, and combustion chambers made of ethical materials, capable of resisting infinite heat.

In the field of ethical research, there would be a wealth of fascinating problems. Would an ethical vehicle travel with an ethical velocity (i.e., infinite speed), or only that of light? In the case of an ethical reciprocating engine, what of the flywheel? If built of an ethical material, with zero specific gravity, would it function as a fly wheel if operated at the theoretical angular speed, infinite revolutions per minute? On the other hand, if an anti-ethical material were used, one of infinite specific gravity, would it function as a flywheel if rotated at an anti-ethical angular speed, zero revolutions per minute? But then, would an ethical machine, which would, of course, operate at 100% efficiency, need a flywheel, fuel tank, bearings, cylinders, or pistons? A few ethical inventions in ethical science, and the world of ethical problems would undergo major simplification, being reduced to only one problem of theoretical importance, ethical man himself.

With such an ethically scientific training, and having acquired the degree of E. E. (Ethical Engineer), such a scientist could be depended upon by other workers in the field of ethics, for, even though he didn't make life more liveable, at least he wouldn't make death more horrible.

These considerations illustrate the blind alleys and dead ends into which our efforts might have been directed but for the discipline of the scientific method. Yet, with all this treatment of ethical science as whimsy, recall that one such ethical material has been reduced to reality. As we approach within a few degrees of Absolute Zero (another goal of ethical science), liquid helium displays zero electrical resistivity, and thus becomes an ethical conductor of electricity. That achievement, however, came about only as a result of the slow, laborious, and rigorous application of the scientific method, involving the painstaking efforts of many workers over a long period of time, in several scientific fields. It certainly was no royal road or ivory tower approach to the attainment of defined perfection, but rather sheer, hard, and often discouraging work. Things are so much easier, and go so much more smoothly by the non-scientific method, for armchair speculation is much simpler, more efficient, and far less expensive than field operation. Then, too, the formulated hypothesis, not subject to experimental test, evolves so much more smoothly and readily into Law, usually grandiose, sometimes majestic, but too often followed to the letter alone.

THE SOCIAL FIELD

If we take an overall look at the social field today, we find that directed effort therein follows along one or the other of two broad points of view, both worthy of comment.

One point of view is to the effect that man is a unique, rather than a special, case, and so hardly amenable to the general laws of nature. One line of action stemming from this point of view is that progress in the social field is to come about solely by education along the lines of the accumulated wisdom (presumably different from knowledge) of the ages, the Great Book Approach; another, somewhat different, viewpoint is that close approximations of the ideal of Ethical Man have appeared in living form from time to time, and that by, and only by, conscious, directed (and sometimes enforced) effort can man-in-the-mass-on-earth attain that rarely demonstrated perfection. Some who hold strictly to this point of view also affirm that the scientific study of man would be more than lese majesty, in fact, would border on the profane, and certainly could lead to no good end. Others who hold to this basic point of view are far from as strict, for, while holding to the viewpoint that man is a unique case, they are willing to subject him to study, providing only that unique methods are used. Thus, all of the group which hold to this broad viewpoint agree that the scientific method, which has proved so useful in the study of other forms of nature, is not applicable to the study of man himself. They aim at progress, but rely on one form or another of the non-scientific method.

The other point of view, held by a small minority of the workers in the social field, is that man himself is not a unique case (though admittedly a special and quite complex one). Hence, this minority hold that the scientific method is applicable to the study of man, as it has proved to be for the rest of nature.

If we cast ourselves back a very short portion of recorded history, we can recognize a similar situation in then embryonic natural science. Man and his material world as well were unique cases. By general, and sometimes imposed, agreement, natural phenomena were linked to super-natural causes, and it was more than lese majesty, in fact, it often proved to be heresy, even to consider that particular natural phenomena had natural causes. In their search for the Elixir of Life and the Philosopher's Stone, our prototypes, the alchemists, might be considered as seeking to practise a normative science, the study of Nature as it should be, immortality in a frame of boundless wealth.

Meantime, the early practitioners of the scientific method, blindfolded by their own ignorance, faltering under mental and physical persecution, but holding grimly to a thin thread of factual reality, stumbled along a narrow footpath, one which gradually opened to the boundless uplands of natural science as we know them today.

THE APPLICATION OF THE SCIENTIFIC METHOD IN THE SOCIAL FIELD

It hardly requires an objective observer to recognize applications of the scientific method to the social field in such social inventions as life, fire, and accident insurance. Those of us who lived in Houston during the past few years experienced an appreciable social change when an apparently hopeless and recurrent downtown traffic snarl was smoothly resolved (and generally accepted with negligible protest) as the result of competent traffic engineering. For those who wish to go further into other results of the scientific method as applied by social scientists in the social field, I recommend Stuart Chase's (1948) "Proper Study of Mankind," a book which should be of more than passing interest to natural scientists. Chase presents such a wide range of material evidence that a review here would not do justice either to his compilation or to the accomplishments of the social scientists mentioned therein. I prefer, instead, to discuss the role which the natural scientist can play in the already started and certain to continue application of the scientific method to the social field.

NATURAL SCIENCE IN THE SOCIAL FIELD

Dr. Warren Weaver [3] has grouped the progress of science in developing techniques for solving problems into two general eras; that prior to 1900, primarily concerned with the two variable problems of simplicity, and that (era) subsequent to the turn of the century, when the development of probability theory and statistical mechanics permitted us to deal effectively with what Dr. Weaver calls the problems of disorganized complexity. He concludes that the pressing major problems of science, particularly the life and social sciences, must be classified into a third group, the problems of organized complexity, for which as yet, he says, we have no clear cut tactical methodology. Some of us might prefer to call these the problems of second order effects, at least in their less complex form. Considered as such, some progress has been made along that line.

In his "Human Frontier," Dr. Williams (1946) has suggested the title "humanics" for the scientific study of human beings. In contrast to that biological robot, man-in-the-abstract, Dr. Williams calls attention to the wide variety of ways in which individuals exhibit marked differences in reaction to the same stimuli. Many of these differences are not only detectible, but also measurable. Certainly, Dr. Williams' studies mark considerable progress up the first two rungs (observation and classification) of the scientific method.

Also taking issue with the concept of the average man, Dr. Sheldon (1940, 1942) has developed a constitutional phychology which, starting with observed body measurements leading to a frame of reference in terms of body types, has been carried over into a similar classification for temperament, with a remarkably high correlation coefficient. Work now under way points to a similar correlation of measured and classified bcdy structure with natural immunology towards diseases and susceptibility to particular mental illnesses.

These studies by Williams and by Sheldon, certainly encouraging starts on the solution of important problems of organized complexity, have far-reaching implications with respect to social behavior and environment. If an individual is to be given reasonable opportunity to develop his natural potential, consideration must be given to the nature of the environment in which he develops, which now tends to be more ready than tailor made. By demonstrating actual, rather than postulating hoped for, social gains, our social engineers of the near future may be able to justify the greater cost of drilling square holes for square pegs. Tolerance, too, might become more realistic, if recognized as a measurable social value instead of as an ephemeral ethical goal.

In developing a methodology for solving problems of organized complexity, Dr. Weaver anticipates material help from two techniques brought into prominence during the years of war effort.

One of these is the "mixed team" approach of operation analysis, wherein competent scientists, specialists in widely separated fields, combine their efforts and experience in the solution of problems to which, operating singly, they could hardly do justice. Dr. Weaver says that such groups found they could work together, and that, in such cases, the mixed team formed a whole which was more powerful than the sum of its parts.

The other approach is the progress being made in the development of electronic computing machines, now being built in sizes and capacities which approach the gigantic. In very short periods of time, these machines can calculate answers to quite complex problems involving several variables. These machines have prodigious memories, being able to store information and use it as needed and, further, include automatic checks, so that the machine can recognize when it has made an error, and call attention to the mistake.

These two approaches have been combined in the new borderline field of "cybernetics," (Wiener, 1948) which attempts to find the common elements in the functioning of automatic machines and the human nervous system, and to develop a theory which will cover the entire field of control and communication in machines and in living organisms. Dr. Wiener, a mathematician, and a pioneer in this field, teamed up with specialists in various fields of natural and social science, physicists, physiologists, economists, psychologists, sociologists, engineers, anatomists, neuro-physiologists, and others. Interesting progress has been reported in setting up electronic devices which, in many respects, are striking analogies of the human brain in operation. We can be reasonably sure that such operation analysis teams will rely, primarily, upon the scientific method.

Thus, there is much evidence that the scientific method can be and is being applied in the social field. While the progress may appear meager, and the constructive applications disappointingly slow, such is all which can be expected in the beginnings of even an exponential curve.

But, what can be expected from such a social science when that reasonably expected exponential curve has taken shape and form? The Ethical Man, and a Heaven on Earth, the goal of those who prefer the non-scientific method in the social field?

Probably not. If our prototypes, the alchemists, were normative scientists, then consider that, with all our progress in natural science, we have attained (apparently) immortality, for a portion of a chicken's heart, and, on a minute scale, have transformed gold into mercury, the inverse of the Philosopher's Stone. If the men of ethics and religion are the analogous prototypes of our social scientists of tomorrow, then the rarely and difficultly achieved perfection of the future may be just as different from the too easily defined perfection of today. About all we can be sure of is that our children's world, and that of their children, will be vastly different from ours, that they will be just about as human as we are, and fall about as short of defined perfection as we do now. Probably some of them will regard our pre-atomic world with nostalgia, and blame the operation of the scientific method for many of their current ills and crises. On the other hand, some of them, more realistic, will regret, as do some of us, the wasted efforts and futile hopes too often associated with and following from the intensive pursuit of the non-scientific method. That vast frustration is in such marked contrast with the reality of progress which followed from the application of the scientific method in the natural field, and which can, quite reasonably, be expected to follow from its application in the social field as well.

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THE MAMMALS OF THE SIERRA VIEJA REGION, SOUTHWESTERN TEXAS, WITH REMARKS ON THE BIOGEOGRAPHIC POSITION OF THE REGION

W. Frank Blair and Clay E. Miller, Jr.
Department of Zoology
University of Texas

INTRODUCTION

The Sierra Vieja range of Trans-Pecos Texas has not been previously studied by animal geographers or ecologists. The location of this range between the comparatively low Rio Grande Valley to the west and southwest and the relatively high grasslands of the Valentine Plain to the east and northeast makes it an interesting region for work in ecological biogeography. The present report deals with the ecological distribution of the mammals of the Sierra Vieja region as determined by field work in the summers of 1947 and 1948.

The Sierra Vieja region, as well as most of Trans-Pecos Texas, lies in the Chihuahuan biotic province as limited by Blair (1940) and Dice (1943). The ecological distribution of the mammals in other parts of the Chihuahuan province in Texas has been studied in the Davis Mountains by Blair (1940), in the Chisos Mountains by Borell and Bryant (1942) and in Culberson County by Davis and Robertson (1944). The Guadalupe Mountains, which were studied by Davis (1940), are referred by Dice (1943) to a different biotic province, the Navahonian.

The work here reported represents one phase of an ecological distribution study of the vertebrates of the Sierra Vieja region. The physical and vegetational environment was studied by York (unpublished). The ecological distribution of the resident birds was investigated by Phillips and Thornton (unpublished). The ecological distribution of the reptiles and amphibians was studied by Jameson and Flury (In Press).

Most of the field work was done on the C. Espy Miller ranch, on the eastern slope of the Sierra Viejas and on the adjacent plains. Other work was done on the Roosevelt ranch, between the Miller ranch and the town of Valentine, and on the Rio Grande about five miles northwest of the town of Porvenir. The senior author and 22 advanced students in the biological sciences at The University of Texas spent the period of June 3 to July 9, 1948 in the Sierra Vieja region. The junior author, J. B. Nance, and the late Harry E. Steincamp studied the distribution of the carnivorous mammals of the region. Paul W. Collier, R. E. Fuge, K. E. James, R. J. Kemp, R. S. Osborn, C. L. York, V. H. Roan, W. W. Webster and Robert Zschappel investigated the distribution of the small mammals. James L. Reagan and Sam M. Awalt studied the ecology of the pocket-gophers. Alfred W. Anderson studied the food habits and general ecology of the mule deer. We are indebted to our co-workers for their contributions to this survey of the ecological distribution of the mammals of the Sierra Vieja. Some additional data are available from three days of field work in the Sierra Vieja by the authors and D. G. Walker in August, 1947 and three days work by the authors in April, 1948.

We are particularly indebted to C. Espy Miller for permission to do field work on his ranch and for the donation of valuable specimens. We are indebted to James Bankert for donating valuable specimens of mammals. We are indebted to Henry Leithead of the Soil Conservation Service for providing us with aerial maps of the region. We are indebted to C. C. Sanborn for examining most of our specimens of bats of the genus **Myotis.**

ECOLOGICAL DISTRIBUTION OF THE MAMMALS

The region studied lies in what we consider to be two biotic districts of the Chihuahuan province. The mountain mass, at least that part of it east of the "rim", lies in what we will call the Sierra Vieja district. The valley of the Rio Grande lies in another district which we will call the Rio Grande Basin district. Two life belts occur in the Sierra Vieja district. The Plains belt includes the relatively level grassland and desert of the Valentine Plain. The Roughland belt includes the mountain mass of the Sierra Vieja from the base of the mountains to the rim and possibly extends beyond the rim. In the Sierra Vieja district six ecological associations [1] were investigated in the Roughland belt, and seven were studied in the Plains belt. In the Rio Grande Basin district, five ecological associations were investigated. The physical features and the vegetation of several associations have been described by York (unpublished). The present report considers the distribution of the different species of mammals in these associations.

PLAINS LIFE BELT

The Plains life belt includes the broad,relatively level plain that extends eastward from the base of the Sierra Vieja to the Davis Mountains. The boundary between the Plains belt and the Roughland belt of the Sierra Vieja district lies at an altitude of about 4500 feet. One ecological association, the catclaw—cedar association, here assigned to the Plains belt, is transitional between the two belts and could be included with some justification in either belt. This association occurs on the alluvial fans at the mouths of some of the canyons. The catclaw—tobosa association occurs also on the alluvial fans but generally at a greater distance from the mountain mass than the catclaw—cedar association. The tobosa—grama association is the most widely distributed of the Plains belt associations. The creosote bush—catclaw—blackbrush, mesquite—huisache—blackbrush, yucca—blackbrush—grama, and blackbrush—creosote bush associations occur under varying edaphic conditions.

Fourteen species of mammals are known, in the Sierra Vieja district, from the Plains belt but not from the Roughland belt (Table I). The known ecological distribution of mammals in the associations of the Plains Belt (Table I) is discussed below. Because the numbers of mammals may fluctuate from year to year, the statements made here are

[1] An ecological association, as here defined, includes the plants and animals that occur together in a relatively stable environment.

Table I

Records of Mammals from the Ecological Associations of the Plains Life Belt, Sierra Vieja Biotic District. The symbol x indicates sight records or other evidence, where specimens were not collected.

SPECIES OF MAMMALS	RECORDS FROM ECOLOGICAL ASSOCIATIONS						
PLAINS BELT SPECIES	Tobosa-Grama	Catclaw-Tobosa	Creosote-Bush-Catclaw-Blackbrush	Mesquite-Huisache-Blackbrush	Yucca-Black-brush-Grama	Blackbrush-Creosote-Bush	Catclaw-Cedar
Sylvilagus audubonii		1	x	x		x	1
Cynomys ludovicianus	1						
Cratogeomys castanops	6	2					
Dipodomys spectabilis	x	x		2		x	1
Dipodomys merriami		45	55	24	4	7	
Reithrodontomys megalotis	1				2		
Peromyscus maniculatus						2	
Onychomys torridus						3	
Neotoma micropus				1		7	
Canis latrans						2	
Taxidea taxus	x					x	
Mephitis macroura	1						
Spilogale leucoparia	1	2					2
Antilocapra americana	x						
WIDE RANGING SPECIES							
Pipistrellus hesperus	3						1
Lepus californicus	x	2	x	x	x	x	x
Perognathus merriami	10	19	5	11	6	18	2
Peromyscus eremicus						2	
Procyon lotor		x					
Mephitis mephitis	5						
Conepatus mesoleucus		1					
Odocoileus hemionus	x						x
ROUGHLAND BELT SPECIES THAT RANGE INTO EDGE OF PLAINS BELT							
Perognathus nelsoni			1				
Myotis yumanensis							1
Myotis volans							1
Lasiurus cinereus							1
Tadarida mexicana							1
Citellus interpres							x
Peromyscus pectoralis							1
Urocyon cinereoargenteus							1
Bassariscus astutus							1

strictly applicable only to the times of field work. Populations were at a very low level in 1947. Some recovery was evident in 1948, but the populations were still rather low.

Tobosa-Grama Association.—The tobosa-grama association was trapped about one-fourth of a mile east of the Miller house by Blair and Miller from April 17 to 19, 1948. It was trapped by Blair southwest of the Kimball house on June 8 and 9, 1948. It was trapped by Roan and York from June 23 to 26, 1948, southwest of the Miller house.

No species of mammal except possibly the prairie-dog (**Cynomys ludovicianus**) is limited to the tobosa-grama association. The hooded skunk (**Mephitis macroura**) was taken in no other association, but this wide-ranging carnivore probably occurs in other associations of the Plains belt. The Merriam pocket-mouse (**Perognathus merriami**) appears to be the most abundant and characteristic small mammal. The other mammals are wide-ranging or tolerant species that occur in several associations of the Plains belt.

Catclaw-Tobosa Association.—This association was investigated in a triangular area lying between the Miller house, the Kimball house, and the Glidewell well. This association occurs far out on the alluvial fans. Alluvial boulders are present in places. Some wind action on the soil is evident in the slight mounding about the bases of the catclaw bushes. Blair, Miller and Walker trapped this association from July 22 to 24, 1947. Roan and York trapped it from June 9 to 15, 1948. Kemp and James trapped it from June 10 to 14. Webster and Collier trapped it from June 16 to 21. Blair trapped it from June 8 to 10, 1948. Blair and Miller trapped it from April 17 to 19, 1948.

The four-toed kangaroo-rat (**Dipodomys merriami**) was by far the most common small mammal in both years. This species, along with the Merriam pocket-mouse (**Perognathus merriami**), comprised the bulk of the small mammal population of the catclaw-tobosa association. Jackrabbits (**Lepus californicus**) and desert cottontails (**Sylvilagus audubonii**) were common both years in this association.

Creosote Bush-Catclaw-Blackbrush Association.—An area of this association parallels the base of the mountains just north of the Roosevelt well. Fuge and Zschappel trapped this area on June 21, 1948. Collier and Webster trapped it from June 22 to 26, 1948.

The four-toed kangaroo-rat (**Dipodomys merriami**) was the most common small mammal. One rock pocket-mouse (**Perognathus nelsoni**), taken here, was probably a wanderer from the Roughland belt. This species was taken in no other association of the Plains belt. No attempt was made to collect the carnivores of this association.

Mesquite-Huisache-Blackbrush Association.—This association was studied in the southeast corner of the Miller ranch, a short distance southeast of the Burford well. Blair, Collier, Fuge, Webster and Zschappel trapped here from June 28 to July 3, 1948. Roan and York trapped here from June 29 to July 3. No trapping of carnivores was done in this association.

This association differs little in its mammalian components from the catclaw-tobosa and creosote bush-catclaw-blackbrush associations. The plains packrat (**Neotoma micropus**) was the only mammal taken in this association that was not found also in the catclaw-tobosa association. Many old packrat nests indicated that this species is common at times in this association. Desert cottontails (**Sylvilagus audubonii**) and jackrabbits (**Lepus californicus**) appeared to be less common here than in the catclaw-tobosa and catclaw-cedar associations.

Yucca-Blackbrush-Grama Association.—This association was investigated at the eastern edge of the Miller ranch, east of the Kimball house. Blair, Fuge and Zschappel trapped here the nights of June 18 and 19, 1948.

The Merriam pocket-mouse (**Perognathus merriami**) and four-toed kangaroo-rat (**Dipodomys merriami**) were the most common species. The harvest mouse (**Reithrodontomys megalotis**) was the only species found here that was not taken in the other brush associations of the Plains belt. The only other association in which this species was taken was the tobosa-grama association.

Blackbrush-Creosote Bush Association.—This association occurs on an area of unsorted alluvial sand, gravel and small boulders about seven miles west of Valentine. Blair, York and Anderson trapped this area the night of June 13, 1948. Collier, Roan and Webster trapped this area from July 5 to 8. No trapping was done for large mammals.

The mammalian aspect of this association is different from that of any other association of the Plains belt. Species that were taken here and in none of the other associations include the cactus mouse (**Peromyscus eremicus**), deermouse (**Peromyscus maniculatus**) and grasshopper mouse (**Onychomys torridus**). The plains packrat (**Neotoma micropus**) was much more abundant than the mesquite-huisache-blackbrush association. The Merriam pocket-mouse (**Perognathus merriami**) was decidedly more abundant than the four-toed kangaroo-rat (**Dipodomys merriami**). The kangaroo-rat exceeded the pocket-mouse in numbers in all of the other associations in which both were found. Desert cottontails (**Sylvilagus audubonii**) and jackrabbits (**Lepus californicus**) were common in this association.

Catclaw-Cedar Association.—This association occurs on the alluvial fans of the Plains belt and borders the canyon mouths. It was trapped by Blair from June 6 to 7, 1948. Miller, Nance and Steincamp trapped this association for carnivores from June 21 to July 8, 1948. Bats were collected by shooting and by use of a stretched wire over a tank in this association.

This association is intermediate in position and in mammalian species between the Plains and Roughland life belts. It is arbitrarily referred to the Plains belt. Roughland belt species include the five species of bats, the antelope squirrel (**Citellus interpres**), the encinal mouse (**Peromyscus pectoralis**), the gray fox (**Urocyon cinereoargenteus**) and the ringtail (**Bassariscus astutus**). Characteristic Plains belt species include the jackrabbit (**Lepus californicus**), desert cottontail (**Sylvilagus audubonii**), four-toed kangaroo-rat (**Dipodomys merriami**) and the little spotted skunk (**Spilogale leucoparia**). Most of the species were rather scarce in this association. This might be expected in such a transitional community. Jackrabbits and desert cottontails were common here, and they appeared to be at least as numerous here as in any association of the Plains belt.

ROUGHLAND LIFE BELT

The Roughland life belt includes the mountain mass of the Sierra Vieja from the base of the mountains at an altitude of about 4500 feet to the top of the mountains. The western slope of the mountains was not investigated, but some part of the western slope possibly should be included in this life belt. Six ecological associations are recognized in the Roughland belt. The stream bed association occurs on the floors of the eastward draining canyons. The catclaw-grama association occupies the canyon slopes and certain inter-canyon alluvial flats which are above the present beds of the canyons. The grama-bluestem association occurs on some of the steep canyon slopes. The rock bluff association is limited to the massive, more or less vertical rock bluffs of the canyon walls. The lechuguilla-beargrass association occurs over most of the level or more or less rolling summits of the mountain mass. The huisache-lechuguilla association occurs under favorable edaphic conditions on the level to rolling mesa top.

Twenty-three species of mammals are largely restricted to the Roughland belt, although a few of these may extend a short distance away from the mountains into transitional associations (Table II). The known ecological distribution of mammals of the Roughland life belt is discussed below.

Stream Bed Association.—This association occurs on the floors of canyons. The only free water regularly available in the Roughland belt is that of the water holes in this association. Small mammals were trapped in this association in Box Canyon above its junction with ZH Canyon. Kemp and James trapped there from June 6 to 9, 1948. Miller, Nance and Steincamp trapped for carnivores in this association from June 5 to 20, 1948.

The mammals of this association were largely the species that occurred also in the more extensive catclaw-grama association. The hog-nosed skunk (**Conepatus mesoleucus**) was taken in no other association of the Roughland belt, and it probably is largely restricted in the Roughland belt to this association. The big brown bat (**Eptesicus fuscus**) was taken only in this association, but it is likely that it occurs in others of the Roughland belt. Bats as a group, and particularly canyon bats (**Pipistrellus hesperus**), were more abundant here than in any other association of the region.

Catclaw-Grama Association.—This association was investigated on the slopes of ZH, Cottonwood and Box Canyons. York and Roan trapped there from June 6 to 8, 1948. Fuge and Zschappel trapped there from June 6 to 10, and Webster and Collier trapped there from June 6 to 15. Blair, Miller and Walker trapped this association from July 22 to 24, 1947, and Blair and Miller trapped it from April 17 to 19, 1948. Miller, Nance and Steincamp trapped for carnivores from June 5 to 20, 1948.

This was one of the major associations of the Roughland belt. Twenty-two of the 32 species of mammals recorded from the Roughland belt were taken in this association. The most abundant species of small mammal was probably the encinal mouse (**Peromyscus pectoralis**). The rock squirrel (**Citellus variegatus**), antelope squirrel (**Citellus interpres**) and the rock pocket-mouse (**Perognathus nelsoni**) were fairly common

Table II

Records of Mammals from the Ecological Association of the Roughland Life Belt, Sierra Vieja Biotic District. The symbol x indicates sight records or other evidence of presence, where specimens were not collected.

SPECIES OF MAMMALS	RECORDS FROM ECOLOGICAL ASSOCIATIONS					
ROUGHLAND BELT SPECIES	Stream Bed	Catclaw-Grama	Grama-Blue-Stem	Rock Bluff	Lechuguilla-Beargrass	Huisache-Lechuguilla
Myotis thysanodes		1				
Myotis yumanensis	1	1				
Myotis californicus	4					
Eptesicus fuscus	2					
Lasiurus cinereus	x					
Plecotus rafinesquii		5				
Antrozous pallidus	2	2				
Tadarida mexicana		1				
Sylvilagus robustus	1	1				1
Citellus variegatus	x	9	x	1		
Citellus interpres	1	3		x		
Thomomys bottae		4			8	2
Perognathus nelsoni	1	6	1			
Peromyscus pectoralis	3	13	12	5	9	
Sigmodon ochrognathus			1			
Neotoma albigula			1			
Erethizon epixanthum		x				
Urocyon cinereoargenteus	x	4	x			x
Bassariscus astutus	2	2		x		
Felis rufus	1	4	x	x		
Felis concolor		2				
Tayassu angulatum		x				
WIDE RANGING SPECIES						
Pipistrellus hesperus	31	4				
Lepus californicus		x				
Perognathus merriami		1				6
Peromyscus eremicus					1	
Mephitis mephitis					1	
Conepatus mesoleucus	2					
Procyon lotor	x					
Odocoileus hemionus	x	x	x		x	
PLAINS BELT SPECIES THAT RANGE INTO EDGE OF ROUGHLAND BELT						
Cratogeomys castanops		1				

in this association. Bats fed in considerable numbers over this association.

Grama-Bluestem Association.—This association was found only on steep slopes of the canyon sides. The encinal mouse (**Peromyscus pectoralis**), which was the most common small mammal, was more abundant here than in any other association. The mountain cotton rat (**Sigmodon ochrognathus**) appears to be limited to this association. The white-throated packrat (**Neotoma albigula**) was taken in no other association, but old signs, presumably made by this species, were seen elsewhere in the Roughland belt.

Rock Bluff Association.—This association occurs on the sheer rock walls of the canyons. Miller, Nance and Steincamp trapped here for small mammals from June 25 to July 8, 1948. No trapping was done for carnivores in this association.

Relatively few species of mammals were recorded from the rock bluff association. The species recorded there are species that range widely in these associations of the Roughland belt. The canyon bat (**Pipistrellus hesperus**) and some of the other bats taken in the stream bed and catclaw-grama associations probably roost in the crevices of the rock bluffs.

Lechuguilla-Beargrass Association.—This association occurs widely over the comparatively level to rolling mesa tops. Kemp and James trapped there for small mammals from June 15 to 27, 1948. Zschappel and Fuge trapped there from June 11 to 17. Miller, Nance and Steincamp trapped there for carnivores from June 5 to 20.

The mountain pocket-gopher **Thomomys bottae**) is probably the most abundant small mammal of this association. It was more numerous here than in any other association. The striped skunk (**Mephitis mephitis**) and the cactus mouse (**Peromyscus eremicus**) were taken in the Roughland belt only in this association. Both of these species were taken also in the Plains belt. The thin soil and great exposure to sun and wind probably account for the comparatively desertic conditions of this association. Scarcity of food and cover for most species and the paucity of retreats possibly account for the scanty mammalian fauna of the lechuguilla-beargrass association.

Huisache-Lechuguilla Association.—An area of this association in Vieja Pass was trapped for small mammals by Reagan from June 19 to 25, 1948. No trapping was done there for carnivores.

The huisache-lechuguilla association differs considerably from the other association of the mesa top, the lechuguilla-beargrass association. Merriam pocket-mice (**Perognathus merriami**) appeared to be common here, but were not taken in the lechuguilla-beargrass association. The mountain cottontail (**Sylvilagus robustus**) was taken here but not in that association.

RIO GRANDE BASIN DISTRICT

The valley of the Rio Grande in western Presidio County seems best considered a different biotic district from the Sierra Vieja mountain mass and the Valentine Plain. The distribution of the birds and reptiles, to be discussed later, affords the strongest argument for separation of the Rio Grande Basin as a distinct biotic district.

Five ecological associations have been investigated at a station about five miles northwest of Porvenir, Texas. The cottonwood association borders the Rio Grande. The mammals of this association were not studied. The salt cedar-mesquite association occurs on the flood-plains adjacent to the river. The catclaw-creosote bush association occurs on sandy flats bordering the salt cedar-mesquite association. The old field association results from clearing of the salt cedar-mesquite association of the river flood-plain. The ocotillo-creosote bush association occurs on the low gravelly hills adjacent to the flood-plain of the river.

Only one species of mammal, the desert pocket-mouse (**Perognathus penicillatus**), was found in this district but not in the Sierra Vieja district. This was the most abundant small mammal of the Rio Grande Basin district. The four-toed kangaroo-rat (**Dipodomys merriami**) is of a different geographic race (**ambiguus**) from the race **merriami** of the Plains belt of the Sierra Vieja district (see Blair, in press). The ecological distribution of the mammals of the Rio Grande Basin district, so far as it is known, is as follows.

Salt Cedar-Mesquite Association.—Miller trapped small mammals in this association on the night of June 16, 1948. Mammals were scarce here, and the short period of trapping gives little information other than that they were scarce. Two desert cottontails (**Sylvilagus audubonii minor**) and one desert pocket-mouse (**Perognathus penicillatus eremicus**) were taken here.

Catclaw-Creosote Bush Association.—Miller trapped small mammals in this association on June 15 and 17, 1948. Kemp and James trapped here from June 15 to 17. No trapping was done for carnivores. The desert pocket-mouse (**Perognathus penicillatus**), with 34 recorded, was the most abundant small mammal. The four-toed kangaroo-rat (**Dipodomys merriami**) with 28 records, was almost as numerous as the pocket-mouse. One Merriam pocket-mouse (**Perognathus merriami gilvus**) was taken.

Old Field Association.—Flury and Jameson trapped for small mammals in the old field association the night of July 1, 1948. The small mammals of this association are the common mammals of the catclaw-creosote bush association. Six desert pocket-mice and three four-toed kangaroo-rats were caught here.

Ocotillo-Creosote Bush Association.—No trapping was done in this association, and the association list of mammals is therefore incomplete. One antelope squirrel (**Citellus interpres**) was shot in this association.

ANNOTATED LIST OF SPECIES

A total of 46 species of mammals was recorded from the Sierra Vieja district and the nearby Rio Grande Basin district. The taxonomic arrangement of the mammals in the following list follows that of Simpson (1945). All specimens here referred to are deposited in the Texas Natural History Collection of the Department of Zoology, University of Texas.

Myotis yumanensis yumanensis (H. Allen). Yuma Bat. This bat was taken only in the Roughland belt and on the ZH alluvial fan adjacent to that belt. Two specimens were collected in the stream bed association of lower ZH Canyon, and one was taken in the catclaw-grama association at the old fort. One was shot over a tank in the catclaw-cedar association of the ZH alluvial fan.

Myotis thysanodes thysanodes Miller. Fringe-tailed Bat. One specimen fitting the description of this species as given by Miller and Allen (1928) was collected at the old fort in the catclaw-grama association near lower ZH Canyon. This species has been recorded from the Chisos Mountains by Borell and Bryant (1942).

Myotis volans interior Miller. Brown Bat. One specimen of this species was collected over a tank in the catclaw-cedar association of the ZH alluvial fan. This is the second record, of which we know, of this bat in Texas. One specimen was reported by Blair (1940) from the Davis Mountains.

Myotis californicus californicus (Audubon and Bachman). California Bat. This bat was taken only in the Roughland belt. Four individuals were shot over the stream bed association of ZH and Cottonwood Canyons. This appears to be a common and widespread species in the Chihuahuan biotic province of Texas. Davis and Robertson (1944) took this species in Culberson County. Borell and Bryant (1942) reported the species from the Big Bend region.

Pipistrellus hesperus maximus Hatfield. Canyon Bat. This was the most common bat in the Roughland life belt of the Sierra Vieja region, and it occurred also in the Plains life belt. These little bats were the first to fly in the evening. They fed mostly over the catclaw-grama association and over the Emory's oaks and other trees of the stream bed association. They were also frequent visitors at the water holes in ZH, Cottonwood and Box Canyons.

Thirty-one canyon bats were shot over the stream bed association of ZH and Cottonwood Canyons. Three were shot over the catclaw-grama association of the canyon sides. One was taken in a building at the old fort in the catclaw-grama association. The species was taken at water holes in two associations of the Plains belt. Two were shot over the tobosa-grama association near the Miller house on July 24, 1947, and one was shot over a tank just east of the Miller house in the same association in June, 1948. One was taken in the catclaw-cedar association of the ZH alluvial fan by means of a wire stretched over a tank.

Eptesicus fuscus pallidus Young. Big Brown Bat. Two specimens were shot over water holes in the stream bed association of lower ZH Canyon. One was taken on June 5, the other on June 8, 1948.

Lasiurus cinereus (Beauvois). Hoary Bat. One specimen was shot over a tank at the mouth of ZH Canyon in the catclaw-cedar association on June 7, 1948. Although no other specimens were taken, large bats that were presumably of this species were seen at various places in ZH and Cottonwood Canyons, where they were feeding about the Emory's oaks in the stream bed association. These bats flew very late, and they usually did not appear until nearly dark.

Plecotus rafinesquii pallescens (Miller). Long-eared Bat. Five specimens were taken in the buildings of the old fort in the catclaw-grama association. Two of these were caught on July 23, 1947. The others were taken in June, 1948. This species was not taken in the Plains belt.

Antrozous pallidus pallidus (LeConte). Pallid Bat. Two specimens were caught in the buildings of the old fort in the catclaw-grama association. Two were shot over water holes in the stream bed association of middle and lower ZH Canyon. This species was not taken in the Plains belt.

Tadarida mexicana (Saussure). Mexican Freetail Bat. This bat was rather scarce in the region, and only two specimens were collected. One was caught in a building at the old fort in the catclaw-grama association on April 18, 1948. One was taken June 11, 1948, by means of a wire stretched over a tank at the mouth of ZH Canyon in the catclaw-cedar association.

Lepus californicus texianus Waterhouse. Jackrabbit. This species was common in some associations of the Plains belt, and a few individuals were seen in the edge of the mountains. Jackrabbits were abundant in the catclaw-cedar and catclaw-tobosa associations of the alluvial fans in July, 1947, and in the spring and sumer of 1948. They were also seen in all of the other associations of the Plains belt. Two specimens were collected in the catclaw-tobosa association of the ZH alluvial fan. A few individuals were seen in the Roughland belt, in the catclaw-grama association of lower ZH Canyon.

Sylvilagus audubonii minor (Mearns). Desert Cottontail. This species was common in some associations of the Plains belt, but it was not found in the Roughland belt. It was most numerous in the blackbrush-creosote bush association about seven miles west of Valentine. At this place the rabbits were utilizing old burrows of the banner-tail kangaroo-rat (**Dipodomys spectabilis**). One specimen was collected in the catclaw-tobosa association near the Kimball house. One was collected in the catclaw-cedar association of the ZH alluvial fan, where the species was fairly common. Several were seen in the creosote bush-catclaw-blackbrush association near the Roosevelt well, and a few were seen in the mesquite-huisache-blackbrush association near the Burford well. The species showed an obvious preference for associations including desert scrub vegetation.

Two specimens were collected in the salt cedar-mesquite association along the Rio Grande, about five miles northwest of Porvenir.

Sylvilagus robustus (Bailey). Mountain Cottontail. This species was restricted to the Roughland life belt, where it was scarce. One was shot by Burke in the catclaw-grama association of lower Box Canyon. One was shot by Flury in the stream bed association of Box Canyon. One was taken by Miller in the huisache-lechuguilla association of Vieja Pass. One was seen by Blair in the catclaw-grama association of lower ZH Canyon. These rabbits were very shy, and they were usually nocturnal in their activities.

Cynomys ludovicianus arizonensis Mearns. Prairie-dog. A prairie-dog town was located, and one specimen was collected in the tobosa-grama association about 10 miles north of the Miller ranch house. Control measures are probably responsible for the relative scarcity of prairie-dogs in this area.

Citellus variegatus couchii (Baird). Rock Squirrel. Rock squirrels were common in the canyons of the Roughland life belt. This species was most commonly found in the rock bluff association and on the rock slides of the catclaw-grama association. The rock squirrels were most active during the middle of the day and the early afternoon. One was shot by Miller in the rock bluff association of ZH Canyon on July 24, 1947. Nine were collected in ZH, Box and Knox Canyons in June and July, 1948. Three of four specimens collected between June 10 and 16 had molt lines on the neck or shoulders. Two of three collected on June 28 had similar molt lines. Two collected on July 6 were in fresh pelage and showed no molt lines. Much of the color variation in this series is due to the fading of melanin pigments in the old pelage of the rump and tail. The older the pelage the more reddish it appears. This fading is not unexpected in a species that is active on bare rock during the sunniest part of the day. The animals in faded pelage are rather inconspicuous on the predominant rocks of the region, which are weathered to a reddish color.

Citellus interpres (Merriam). Antelope Squirrel. This shy little ground squirrel was common in several associations of the Roughland belt and occurred also in the catclaw-cedar association of the alluvial fans. Like the rock squirrels, these animals were most active during the hottest parts of the day. The antelope squirrels were most numerous in the catclaw-grama association, but individuals were seen even on sheer bluffs of the canyon walls (rock bluff association). Dens of the antelope squirrels were usually located beneath massive boulders on relatively level ground. Foods most commonly found in the vicinity of the burrows included the fruits of the Mexican walnut (**Juglans rupestris**), the Texas mountain laurel (**Sophora secundiflora**) and the Mexican buckeye (**Ungnadia speciosa**). Four specimens were collected in lower Knox, ZH, and Box Canyons of the Miller ranch. One was collected by Blair in the ocotillo-creosote bush association about five miles northwest of Porvenir.

Thomomys bottae pervarius Goldman. Mountain Pocket-gopher. This pocket-gopher appears to be limited to the Roughland belt, where it is an abundant and widely distributed species. One was taken in the catclaw-grama association on an alluvial flat near the junction of ZH and Box Canyons by Blair in July, 1947. Reagan and Awalt took the species in three associations. Three were trapped at the above locality, and one plains pocket-gopher was also taken there. Two were caught in the huisache-lechuguilla association, and eight were taken in the lechuguilla-beargrass association in Vieja Pass. Mounds were observed on slopes of greater than 45 degrees inclination, but no specimens were taken from these mounds. The mounds of these gophers were closely associated with clumps of lechuguilla in the lechuguilla-beargrass and huisache-lechuguilla associations. In the catclaw-grama association the mounds were usually located in the clumps of catclaw. It is interesting that in this region no mountain pocket-gophers were found in the stream bed association, for in the Davis Mountains Blair (1940) found the species restricted to that association.

One burrow in the lechuguilla-beargrass association was excavated by Reagan and Awalt. It was found to have two main branches and a prominent secondary branch given off by one of these branches. The two main branches entered a nest chamber at an angle of about 40 degrees. These tunnels extended out 20 and 30 feet, respectively, from the nest chamber. Except near the nest, the roof of the tunnels was from two to four inches below the surface of the ground. The nest chamber was situated under a large rock and two feet below the surface of the ground.

Lateral tunnels were few in number and very short (from six inches to one foot long) and terminated in plugged openings. Most of these laterals ended in clumps of lechuguilla plants, reported by Bailey (1905) to be the principal food of this species in western Texas. In many places we noted dead lechuguilla plants in conjunction with mountain gopher workings, and these were apparently killed by destruction of their roots by the gophers.

The nest chamber was circular, 16 inches in diameter, with from four to five inches between the floor and roof. Three tunnels led away from the nest chamber. In addition to the previously mentioned two main tunnels, there was a third tunnel which ended six feet from the nest in a dead end. The nest chamber was littered with dried grass and some fecal matter. No food caches were found, but remnants of food materials were found in the tunnels. These included: lechuguilla roots and meristem, roots of agarita **(Berberis trifoliata)** and hairy grama **(Bouteloua hirsuta).** One animal had its pouches filled with resurrection plant **(Selaginella sp.).**

Compared with the burrow of the plains pocket-gopher, the burrow of the mountain pocket-gopher was less extensive and less branched; it did not connect with the burrows of other individuals; it had a smaller invertebrate fauna; and it was less neat.

Cratogeomys castanops lacrimalis Goldman. Plains Pocket-gopher. This pocket-gopher is largely restricted to the Plains belt in this region, but specimens were taken in one association of the Roughland belt. In the latter belt, one was trapped on an alluvial flat occupied by the catclaw-grama association and located at the junction of ZH and Box Canyons. The mountain pocket-gopher **(Thomomys bottae pervarius)** occurred on this same flat, and three specimens were collected about 350 yards from where the plains pocket-gopher was taken.

In the Plains belt, the plains pocket-gopher was most abundant in the tobosa-grama association, but it was taken also in the catclaw-tobosa association of the ZH Canyon alluvial fan. Numerous mounds were seen at the bases of catclaw bushes, and two specimens were collected in the catclaw-tobosa association. Five specimens were collected in the tobosa-grama association in the 1948 work by Reagan and Awalt. One was taken there by Blair and Miller in July, 1947. In this association the only mounds observed were on or near earthen dams, which are used in this region for the prevention of erosion. The soil was relatively moist near these dams, and the grass cover was greener than in other parts of the basin.

A burrow from which an adult female and a young adult male were trapped in the tobosa-grama association was excavated by Reagan and Awalt. This burrow consisted of three main branches radiating from a fairly central point. The longest of the three branches extended 150 feet westward from the junction of the three. This branch was separated from the burrow of another gopher by 14 inches of loose plugging. A second main branch extended 90 feet north of the junction of the three, and it was separated from the burrow of another gopher by six feet of rather compact plugging. The third main branch extended 60 feet southeast of the junction of the three, and its excavation was abandoned when it passed under an earthen dam.

The depth of the tunnel roof below the surface of the ground varied from two inches near mounds to 21 inches at other places. The lumen of the tunnels measured about 3.5 inches vertically and about three inches laterally. The main branches of the burrow received many secondarily branched lateral tunnels. The terminal branches ended in plugged openings to the surface. The nature of the soil permitted the tracing of tunnels which had been plugged for considerable distances and apparently for considerable periods of time.

Four nest chambers were found along the course of the main run. Three of these were open, while the fourth had been filled with dirt, feces, and dried grass. The nest chambers consisted of spheroidal hollows set about two inches from the main run. The dimensions of the nest chambers were the same in all cases and were as follows: axis parallel to main run, 7.5 inches; axis perpendicular to main run, 5.5 inches; vertical axis, 14 inches. The floor of the nest chamber was four inches below the level of the main run and was filled to that level with dried grass. No fecal matter was found in the nest material.

Two food caches were encountered a short distance from fresh mounds near the junction of the three main branches. These were lateral branches which had, at one time, opened to the surface. They had now been plugged to a point 13 inches from the main run. These side tunnels were loosely filled with tufts of green grama grass which had been cut at the roots. No other food was found in this burrow.

The material used for plugging unused portions of the burrow consisted of soil, fecal matter, and dried grass in varying proportions. The high content of fecal matter and dried grass in some lateral tunnels apparently indicated an attempt at house cleaning on the part of the gopher.

Several invertebrates were collected from the tunnels of gophers both by excavation and by use of molasses traps, but these have not been identified.

Perognathus merriami gilvus Osgood. Merriam Pocket-mouse. This pocket-mouse was taken in both the Plaiins and Roughland life belts. It was the second most abundant mammal of the Plains belt, where it was exceeded in numbers only by the four-toed kangaroo-rat. Merriam pocket-mice were taken in all of the associations of this belt. Nineteen were trapped in the catclaw-tobosa association north of the Miller house. Eighteen were caught in the blackbrush-creosote bush association about seven miles west of Valentine. Five were taken in the creosote bush-catclaw-blackbrush association near the Roosevelt well. Eleven were obtained in the mesquite-huisache-blackbrush association near the Burford well. Ten were caught in the tobosa-grama association. Six were trapped in the yucca-blackbrush-grama association east of the Kimball house. Two were caught in the catclaw-cedar association of the ZH alluvial fan.

This species was uncommon in the Roughland belt. Six were trapped in the huisache-lechuguilla association of Vieja Pass. One was caught by hand at night in the catclaw-grama association near the old fort, between ZH and Box Canyons.

These pocket-mice are rather intermediate in many characters between **Perognathus merriami** from Live Oak, McMullen, Eastland, Fisher and Throckmorton Counties, Texas, and **Perognathus flavus** from Otero County, New Mexico, and Jackson County, Oklahoma. The large interparietal, large body size and comparatively long tail are taken to indicate that all of our material is assignable to the species **merriami.** The size of the lower premolar and the degree of inflation of the mastoids are quite variable and of little value in determining the species of these mice. The pocket-mice from this locality are paler and more buffy and have more conspicuous post-auricular spots than do **merriami** from southern and north-central Texas. The conspicuous postauricular spots resemble those of **flavus.**

On individual was taken in the Rio Grande Basin district. This mouse was taken in the catclaw-creosote bush association about five miles northwest of Porvenir.

Perognathus penicillatus eremicus Mearns. Desert Pocket-mouse. This species appears to be limited in our region to the sandy soils of the Rio Grande Basin district. This pocket-mouse was the most abundant mammal along the Rio Grande about five miles northwest of Porvenir. Thirty-four specimens were taken there in the catclaw-creosote bush association by Miller, Kemp and James. Six specimens were taken in an old field there on the Rio Grande flood-plain. One was trapped there in the salt cedar-mesquite association.

Perognathus nelsoni collis Blair. Rock Pocket-mouse. This species was rather rare in the Roughland belt, where it was taken in three associations. Six specimens were taken in the catclaw-grama association of ZH and Box Canyons. One was taken in the stream bed association of Box Canyon, and one was caught in the grama-bluestem association of lower ZH Canyon. The steep, rock-littered slopes of the canyon walls seem to be preferred by this pocket-mouse.

One individual was taken in the creosote bush-catclaw-blackbrush association of the Plains belt. This animal was trapped just north of the Roosevelt well and about one-half mile from the base of the mountains. It is doubtful that this saxicolous species ranges very far into the Plains belt.

Dipodomys spectabilis baileyi Goldman. Banner-tail Kangaroo-rat. This kangaroo-rat was taken only in the Plains belt, where it seemed to be rather unevenly distributed. One was trapped in the catclaw-tobosa association near the Glidewell well, but a predator robbed the trap and left only the tail as evidence. One was dug out of a den in the mesquite-huisache-blackbrush association near the Burford well, and one was trapped at the same locality. Several active dens were seen there. Several active dens were seen in the tobosa-grama association east of the Miller house in July, 1947. These dens were being used in 1948 by four-toed kangaroo-rats **(Dipodomys merriami)** and by lizards **(Cnemidophorus perplexus** and **Holbrookia maculata).** Old dens were seen in 1948 in the blackbrush-creosote bush association, about seven miles west of Valentine.

Dipodomys merriami merriami Mearns. Four-toed Kangaroo-rat. Specimens of **Dipodomys merriami** from the Valentine Plain are referred to the subspecies **merriami** because of their dull, dark coloration. This was the commonest small mammal in all ecological associations of the Plains belt except the tobosa-grama and catclaw-cedar associations. None was taken in the former and only one in the latter association.

Forty-five were trapped in the extensive area of catclaw-tobosa association between the Miller house, Kimball house, and Glidewell well. Fifty-five were trapped in the creosote bush-catclaw-blackbrush association near the Roosevelt well. Twenty-four were taken in the mesquite-huisache-blackbrush association near the Burford well. Four were obtained in the yucca-blackbrush-grama association east of the Kimball house. Seven were taken in the blackbrush-creosote bush association about seven miles west of Valentine.

This species appeared to be absent from the Roughland belt. One specimen was trapped on the rough stony soil of the catclaw-cedar association on the ZH alluvial fan, but this type of soil appears to be a rather effective barrier to the distribution of this species.

Dipodomys merriami ambiguus Merriam. Four-toed Kangaroo-rat. Specimens of **Dipodomys merriami** from the Rio Grande Basin are referred to the subspecies **ambiguus** because of their pale, relatively bright coloration. This species was abundant on the sandy soil adjacent to the Rio Grande about five miles northwest of Porvenir. Twenty-eight specimens were trapped there in the catclaw-creosote bush association. Three were taken in an old field on the Rio Grande flood-plain.

Reithrodontomys megalotis megalotis (Baird). Harvest Mouse. Harvest mice were found only in the Plains life belt in the Sierra Vieja district. The species was scarce in both 1947 and 1948, and specimens were taken in only two ecological associations of the basin. One was trapped in the tobosa-grama association just east of the Miller house on April 19, 1948, by Blair and Miller. Two were taken in the yucca-blackbrush-grama association east of the Kimball well in June, 1948.

It is surprising that this species was not taken in the Roughland belt of this area. Blair (1940) found this species common in the Roughland belt of the nearby Davis Mountain region, where the species ranged up to an altitude of 6100 feet.

Peromyscus eremicus eremicus (Baird). Cactus Mouse. The cactus mouse was rare in the Sierra Vieja region, but it was taken in both the Roughland and Plains life belts. One was taken by James in the lechuguilla-beargrass association on the mesa south of Box Canyon. Two were taken in the blackbrush-creosote bush association about seven miles west of Valentine. This normally saxicolous species was living far from any rock outcrops where it was taken in the blackbrush-creosote bush association.

Peromyscus maniculatus blandus Osgood. Deermouse. This species was remarkably scarce in our region in both 1947 and 1948, and it was found only in the blackbrush-creosote bush association of the Plains life belt. Two specimens were trapped by Collier in this association about seven miles west of Valentine in July, 1948.

Peromyscus pectoralis laceianus Bailey. Encinal Mouse. Forty-three mice of the **Peromyscus boylii** group were taken in the Sierra Vieja region. Thirty-eight of these mice appear unquestionably to belong to the species **pectoralis.** The tarsal joint is white or nearly so, and in all of these specimens the size of the tail annulations is comparable to the size of the tail rings in specimens of **pectoralis** from Rocksprings, Texas. Skeletal characters are considerably variable, and some skull measurements are intermediate between the measurements given by Osgood (1909) for **Peromyscus b. attwateri** and **Peromyscus p. laceianus.** Length of the palatine slits is a fairly constant character, and, along with the external characters of the small tail scales and white tarsal joint, indicates these mice to be of the species **pectoralis.**

Four of 13 specimens from the catclaw-grama association and one of 12 from the grama-bluestem association are somewhat intermediate between the Rocksprings **pectoralis** and specimens of **Peromyscus b. attwateri** from Limpia Canyon in the Davis Mountains. Some dusky hairs extend onto the tarsal joint, but these dark hairs are much fewer than on the tarsal joint of the Davis mountain **attwateri.** The caudal scales are intermediate in size between those of **attwateri** and those of the other mice from the Sierra Vieja. Pending further investigation of the relationships of these two species in Texas, these intermediate specimens are referred to **pectoralis.**

Brush mice were the commonest small mammals of the Roughland belt. Thirteen were caught in the catclaw-grama association. Twelve were taken in the grama-bluestem association. Nine were trapped in the lechuguilla-beargrass association of the mesa top. Five were taken in the rock bluff association of ZH and Cottonwood Canyons. Three were taken in the stream bed association. One specimen was obtained in the catclaw-cedar association at the mouth of ZH Canyon in the edge of the Plains belt. There is no evidence that this saxicolous species ranges more than a few yards from the base of the mountains.

Onychomys torridus torridus (Coues). Grasshopper Mouse. Grasshopper mice were scarce in the region, and the species was taken in only one association of the Plains life belt. Three were trapped in July, 1948, in the blackbrush-creosote bush association about seven miles west of Valentine. None was taken in the Roughland belt. This was surprising, for Blair (1940) found that in the Davis Mountains this species occurred in the Roughland belt and ranged up to an altitude of 6000 feet.

Sigmodon ochrognathus Bailey. Mountain Cotton Rat. One was trapped by C. E. Miller in the grama-bluestem association near the mouth of ZH Canyon on June 13, 1948. There were old trails and old droppings in this association at this locality. The area of grama-bluestem association in which the specimen was taken and in which the old signs were seen was on a very steep, rock-littered slope. It seems likely that the local distribution of this species is considerably limited by grazing practices in the region. Heavy grazing depletes the grass cover that this species seems to require from all but the steepest slopes. The result is the limitation of this species to those steep slopes.

Neotoma micropus canescens Allen. Plains Packrat. This species was taken in two associations of the Plains life belt, but no evidence of its presence was found in the other associations of that belt or in the Roughland belt. One was trapped in the mesquite-huisache-black-brush association near the Burford well. Numerous old dens were seen at this locality. Seven were trapped in the black-brush-creosote bush association about seven miles west of Valentine. Most of the dens seen at this station were active ones. In some cases the packrats were using the old dens of the banner-tail kangaroo-rat **(Dipodomys spectabilis.)**

Neotoma albigula robusta Blair. White-throated Packrat. This was the only species of packrat taken in the Roughland belt, and it was rare there in both 1947 and 1948. One was trapped on June 6, 1948, on a rock slide in the grama-bluestem association just inside the mouth of ZH Canyon. This animal entered the trap between one and two hours after daylight. Old packrat sign, presumably made by this species, was seen in the catclaw-grama, rock bluff and stream bed associations of ZH Canyon.

Erethizon epixanthum subspecies. Porcupine. There is only one sight record of this species from the region. Miller examined the foot of a porcupine that had been trapped at the head of West Well Canyon on September 14, 1948.

Canis latrans texensis Bailey. Coyote. Coyotes were fairly common in the Plains belt of the Sierra Vieja region. Two were collected by Miller in the blackbrush-creosote bush association. One of them had fed on jackrabbit **(Lepus californicus)**. A skeleton was picked up 12 miles southwest of Chispa. Another skeleton was donated by James Bankert. We saw one old lactating female, trapped by a government trapper on June 13, that had two pegged feet from previous trappings.

Urocyon cinereoargenteus scotti Mearns. Gray Fox. These little foxes were common in the Roughland belt and probably ranged over all of the ecological associations of this life belt. A subadult male was shot by Miller at the old fort in the catclaw-grama association on July 22, 1947. Two specimens were trapped in 1948 in the catclaw-grama association, and one skeleton was picked up there. One of the trapped animals was being attacked by a golden eagle when Miller arrived at the trap. This fox was lactating. One was shot by Miller in the huisache-lechuguilla association of Vieja Pass. One specimen from the catclaw-cedar association was donated by J. Bankert. One was seen in the grama-bluestem association near the mouth of ZH Canyon, and two were seen in the stream bed association of Fox Hollow.

Procyon lotor subspecies. Raccoon. No specimens were collected. Tracks were seen around tanks in the tobosa-grama association of the Plains belt and around water holes in the stream bed association of the Roughland belt. Tracks were seen along the Rio Grande about five miles north of Porvenir.

Bassariscus astutus flavus Rhoads. Ringtail. This is strictly a species of the Roughland belt. Two were trapped in the catclaw-grama association of ZH Canyon, and one was trapped in the stream bed association of the same canyon. One was found dead in the mouth of Knox Canyon. The ringtail probably ranges through all of the associations of the Roughland belt. One was seen at night in a dead Emory's oak in ZH Canyon. It took refuge in the hollow trunk of the oak, which showed signs of much use and had many ringtail droppings about it. One was found dead, presumably by drowning, in a tank at the mouth of ZH Canyon, in the catclaw-cedar association.

Taxidea taxus berlandieri Baird. Badger. This species was found only in the Plains belt. Badger diggings were seen in the catclaw-tobosa association near the Roosevelt well and in the blackbrush-creosote bush association about seven miles west of Valentine. One specimen was donated by James Bankert, and another was donated by C. Espy Miller.

Mephitis mephitis varians Gray. Striped Skunk. This was the commonest skunk of the Sierra Vieja region, and a total of six specimens was collected. The records indicate that this species probably prefers relatively level ground of both the Plains and Roughland life belts. One was taken in the lechuguilla-beargrass association on top of the mesa south of ZH Canyon. This animal was very mangy and emaciated. Five specimens were taken in the tobosa-grama association of the Plains belt. One of these was even more mangy and emaciated than the one from the mesa. It is interesting that this species was not taken in the canyons of the Roughland belt.

Mephitis macroura milleri Mearns. Hooded Skunk. This was the rarest skunk of the Sierra Vieja region, and only one specimen was obtained. This specimen was donated by C. Espy Miller after it had been caught in a trap in the tobosa-grama association at the Miller house. This individual is in the black phase and has only vestiges of the white lateral stripes. The neck ruff is black, as is the entire dorsal surface of the body. There is a very narrow white face stripe.

Spilogale leucoparia Merriam. Little Spotted Skunk. This species was taken only in the Plains belt, where it was recorded from three ecological associations. One was taken on July 22, 1947, near the Miller house in the tobosa-grama association. Two were taken in 1948 in the catclaw-tobosa association of the Knox alluvial fan, and one was taken in the catclaw-cedar association of the ZH alluvial fan. We found no evidence of this species in the Roughland belt, but Blair (1940) found the species in the Davis Mountains at an altitude of 5500 feet in the Roughland belt of that mountain range.

Conepatus mesoleucus mearnsi Merriam. Hog-nosed Skunk. This species was taken in both the Roughland and Plains life belts. One was killed by Alvin Flury in the stream bed association of Knox Canyon. One was found dead in an abandoned steel trap in the stream bed association at the junction of Cottonwood and ZH Canyons. One was found dead in the catclaw-cedar association of the Knox Canyon alluvial fan, and another was found dead in the same association of the ZH Canyon alluvial fan. One was trapped in the catclaw-tobosa association of the Plains belt.

Felis rufus baileyi (Merriam). Wildcat. This species was common in the Roughland belt, but no records were obtained from the Plains belt. One specimen was donated by James Bankert. This one was trapped at 96 well. Four skeletons were picked up in ZH Canyon. One skeleton was found about 12 miles southwest of Chispa. This species probably ranges over all of the associations of the Roughland belt.

Felis concolor stanleyana Goldman. Mountain-lion. This species occurs in the Roughland life belt in spite of constant control measures. Two skulls in the Texas Natural History Collection were donated by C. Espy Miller. One animal was killed in the mountains of the Miller ranch in 1947. The other was killed in West Well Canyon about a week after our field work was discontinued in July, 1948.

Tayassu angulatum angulatum (Cope). Javeline. Two adults and one young of the year were observed by Miller in Hanley Spring Canyon on September 20, 1948.

Odocoileus hemionus crooki (Mearns). Mule-deer. Mule-deer were common in all of the associations of the Roughland belt except the rock bluff association. They were also seen in the catclaw-cedar and tobosa-grama associations of the Plains belt. In the latter association, the deer were seen feeding early in the morning on several different occasions. When disturbed there they ran to the mountains one or two miles distant. A study of the food habits of the mule-deer was made by A. W. Anderson and will be published elsewhere.

Antilocapra americana mexicana Merriam. Pronghorn. This species was scarce in the Plains life belt, and none was seen in the Roughland belt. Three were observed in the tobosa-grama association about six miles north of the Miller house, and one was observed in the same association about four miles east of the house.

FAUNAL RELATIONS OF THE MAMMALS

The mammals of the Siera Vieja biotic district, as might be expected, represent several different faunal elements (Table III). Twelve of the 45 species are widely distributed forms that occur in many biotic provinces of North America. The Roughland belt has a greater proportion of widely distributed species than the Plains belt due to the presence of wide-ranging carnivores and bats. Fourteen species are widely distributed in the western half of North America and occur there in several biotic provinces. Two species, one restricted in our region to the Plains belt and the other found in both life belts, have their center of distribution in the Great Plains of central North America. Twelve species, five restricted to the Plains belt, four restricted to the Roughland belt, and three occurring in both, have their centers of distribution in Mexico and range into our region from the south. Five species are largely restricted to the Chihuahuan biotic province as delimited by Dice (1943). These species include: **Sylvilagus robustus, Citellus interpres, Perognathus nelsoni, Sigmodon ochrognathus,** restricted to the Roughland belt; and **Spilogale leucoparia,** restricted so far as known to the Plains belt. The genus **Spilogale** is badly in need of revision, and it is not unlikely that this presumably endemic species will be found to be a geographic race of a widely distributed species.

The mammalian fauna of the Sierra Vieja biotic district, then, includes a strong element (26.7%) of Mexican species and a strong ica. The Great Plains element (4.4%) is negligible. There is a small element (31.1%) of species widely distributed in western North Amer-

Table III

Faunal Affinities of the Mammals of the Sierra Vieja Biotic District, Southwestern Texas.

	Wide Dist. North Amer.	Wide Dist. W. North Amer.	Great Plains	Mexican	Chihuahuan	Totals
Plains Belt Species	2	4	1	5	1	13
Roughland Belt Species	7	8	—	4	4	23
Species Known from both Belts	3	2	1	3	—	9
TOTALS	12	14	2	12	5	45

element (11.1%) of species that are largely restricted to the Chihuahuan province. Since these are mostly Roughland belt forms, it is to be assumed that they probably originated under conditions of partial isolation in the mountains of this biotic province.

BIOGEOGRAPHIC RELATIONS OF THE SIERRA VIEJA REGION

The biogeography of the Trans-Pecos mountains and basins of Texas is little known, and our knowledge of this region is not yet sufficient for a detailed analysis of the biogeographic relationships of this large and complex area. The data here presented and unpublished data of our colleagues (York, Phillips and Thornton, and Jameson and Flury) nevertheless permit a comparison of the Sierra Vieja region with such other nearby areas as have been studied.

All of Trans-Pecos Texas except the Guadalupe Mountains, we believe, should be included in the Chihuahuan biotic province. This relationship already has been suggested by Blair (1940) and by Dice (1943). The mammalian, avian, reptilian and amphibian faunas of the Sierra Vieja region, as determined by us and our associates, show strong affinities with the respective faunas of the Chihuahuan province of northern Mexico. Approximately 11.1% of the mammals and 19.0% of the reptiles and amphibians are species that are largely restricted to the Chihuahuan biotic province as here limited. About 26.7% of the mammals, 22.5% of the reptiles and amphibians, and 20.6% of the birds are species with Mexican affinities that range into our region from the south. Previous work with the mammals of the Davis Mountain region by Blair (1940), with the mammals of the Big Bend region by Borell and Bryant (1942) and with the mammals of Culberson County by Davis and Robertson (1944) offers good evidence that the affinities of the mammals of most of Trans-Pecos Texas lie with the fauna of northern Chihuahua. Similar evidence is available for the avifauna in the work of Van Tyne and Sutton (1937) in Brewster County, and for the herpetofauna in the work of Schmidt and Smith (1944) in the Big Bend region.

The details of ecological distribution in Trans-Pecos Texas and the limits of such biotic districts as may exist there within the limits of the Chihuahuan province need much further work. Some comparisons are possible, however, between the Sierra Vieja region and the Chisos Mountain region of the Big Bend, and between our region and the Davis Mountain region.

One major ecological difference between the Sierra Vieja and the Davis and Chisos Mountain regions is in elevation. The Sierra Viejas are much lower than these other ranges. The highest point is Vieja Peak, with an elevation of 6467 feet, and most of the mountain mass lies below 6000 feet. The Davis Mountains reach an elevation of 8382 feet (Mount Livermore), and the Chisos Mountains have a maximum elevation of 7835 feet (Emory Peak). Both of these latter ranges have extensive areas above 6000 feet. The Davis Mountains receive more rainfall and are cooler than the Sierra Viejas (see York, unpublished). No weather data are available for the Chisos Mountains, but they too probably receive more precipitation and average somewhat lower in temperature than the Sierra Viejas due to their greater elevation.

Several important ecological associations, lacking from the Sierra Viejas, occur in the Davis and Chisos Mountains because of their greater elevation and more favorable climatic conditions. The oak-juniper, pinyon-juniper, and yellow-pine-juniper associations have been described from the Davis Mountains by Blair (1940). Comparable associations were found in the Chisos Mountains by Borell and Bryant (1942). The absence of these associations from the Sierra Viejas probably accounts for the absence of several species of vertebrates from the Roughland belt of the Sierra Vieja district.

The Plains belt of the Sierra Vieja district seems to differ little from the comparable belt of the Chisos Mountain area. In both of these areas the Plains belt has a lower elevation than the comparable belt of the Davis Mountain region, and the climate of this belt in these regions is apparently dryer and less favorable for plant growth than in the Davis Mountain region. The vegetation of the Plains belt in these areas is, consequently, more desertic than in the Davis Mountain area. Grama grasses (**Bouteloua**, various species) are more important elements in the Plains belt vegetation of the Davis Mountain region than in these others, where desert scrub and tobosa grass (**Hilaria mutica**) are predominant elements.

The part of Trans-Pecos Texas studied by us, the Sierra Vieja Range and the adjacent plains, is, as already indicated, best treated as two biotic districts of the Chihuahuan biotic province. The comparatively low, hot, dry lowlands and low hills of the old Rio Grande Basin comprise the Rio Grande Basin district. The Sierra Vieja, at least east of the "rim", and the Valentine Plain comprise the Sierra Vieja district. This separation is made principally on the basis of the presence of certain ecological associations and of certain vertebrate species in the Rio Grande Basin but not in the Sierra Vieja district as here limited. The salt cedar-mesquite association of the Rio Grande floodplain and the ocotillo-creosote bush association of the adjacent gravelly uplands are characteristic of the Rio Grande Basin district. The most common small mammal, a pocket-mouse (**Perognathus penicillatus**), of the Rio Grande Basin district was apparently absent from the Sierra Vieja district. Eight (24.2%) of 33 species of birds recorded by Phillips and Thornton (In Press) from the Rio Grande Basin district were not found in the Sierra Vieja district. The bird list for the former district is quite incomplete, and future work will probably reveal additional differences in the avifauna of the two districts. Notably common birds of the Rio Grande Basin district that were absent from the Sierra Vieja district include the Gambel's quail (**Lophortyx gambeli**) and the long-tailed chat (**Icteria virens**). Five (33.3%) of 15 species of amphibians and reptiles recorded by Jameson and Flury (In Press) from the Rio Grande Basin district, appeared to be absent from the Sierra Vieja district. Four of these, including **Bufo cognatus, Bufo compactilis, Uta stansburiana** and **Cnemidophorus tessellatus,** were common in the former district, but intensive field work failed to reveal them in the latter district. The list of amphibians and reptiles is obviously incomplete for the Rio Grande Basin district, and further work will probably reveal additional differences in the herpetofauna of the two districts. The differences in ecological associations and in the vertebrate fauna are of such magnitude that it is logical and reasonable to treat the Rio Grande Basin area and the Sierra Vieja—Valentine Plain area as separate biotic districts.

Comparison of the vertebrate fauna of our region with that of other parts of the Chihuahuan province in Trans-Pecos Texas is limited by the paucity of published work on other, nearby areas. The mammalian fauna of the Siera Vieja district may be compared with that of the Davis Mountain biotic district as reported by Blair (1940). Six (13.3%) of 45 species of mammals recorded from the Sierra Vieja districts have not been recorded from the Davis Mountain district. Four of these are bats. The antelope squirrel (**Citellus interpres**) appears to be absent from the Davis Mountain district, but it has been recorded from the base of the Guadalupe Mountains to the north of the Sierra Vieja by Davis (1940). The javelina (**Tayassu angulatum**) probably does not range north of the Sierra Viejas in this part of Texas. Fifteen (27.3%) of the 55 species recorded by Blair from the Davis Mountain district have not been taken in the Sierra Vieja district. Some of these, such as **Citellus mexicanus** and **Reithrodontomys fulvescens**, will probably be found to occur in the Sierra Vieja district. Others, such as **Dipodomys ordii, Perognathus hispidus, Peromyscus boylii, Neotoma mexicana** and others, are probably absent.

Comparison of the vetebrate fauna of our region with that of the Chisos Mountain region is difficult, because previous workers in that area have made little or no biogeographic distinction between the lowlands of the Rio Grande and the mountain masses and plains. It is necessary, therefore, to lump the faunas of the two biotic districts in our region for comparison with the Big Bend fauna. In actuality, the "Lower Sonoran Life Zone" of Borell and Bryant (1942) in the Big Bend region probably corresponds in part to the Rio Grande Basin district of our region. Only two (4.3%) of the 46 species of mammals recorded from our region were not listed also by Borell and Bryant (1942) from the Big Bend. Fifteen (26.1%) of 56 species listed from the Big Bend were not recorded from our region. Two of the Big Bend species have been extirpated in the southern Trans-Pecos, and they may well have occurred over a wide area. One species, **Odocoileus virginianus**, almost certainly occurred in our region, but we obtained no positive records. Several of the remaining 12 species will probably be found in future work in the Sierra Vieja region. It seems unlikely that differences in elevation make for any great differences in the mammalian faunas of the two regions, for, with the possible exception of **Peromyscus boylii**, the species missing from the Sierra Vieja list are not high-elevation species.

Fifty-five (46.6%) of the 118 species of breeding birds listed from Brewster County by Van Tyne and Sutton (1937) were not recorded from the Sierra Vieja region by Phillips and Thornton (In Press). All but three of the species of breeding birds recorded from our region are listed for Brewster County. This considerable difference in the avifauna is probably attributable in part to differences in elevation in the two regions and in part to the limited amount of field work in the Sierra Vieja region.

Thirteen (24.5%) of the 53 species of amphibians and reptiles reported by Jameston and Flury (In Press) from our region have not been taken by previous workers in the Chisos Mountain area. Seventeen (30.4%) of 56 species listed by pervious workers from the Chisos Mountain area have not been taken in the Sierra Vieja area. Some of this apparent difference in the herpetofauna of the two regions may be due in part to differences in field techniques and times of field work. There has been enough work in both regions, however, to suggest that a considerable part of the difference is due to actual differences in the faunas of the two areas.

On the basis of present information, there is, therefore, a considerable difference between the Big Bend region and the region of the Sierra Viejas in the herpetofauna, in the avifauna and in the mammalian fauna. Whether or not the Chisos Mountain area and the Sierra Vieja area should be regarded as separate biotic districts can only be determined by future work in these areas.

SUMMARY

Ecological distribution of the mammals was studied in the Sierra Vieja region of Trans-Pecos Texas from June 3 to July 9, 1948 and on short trips in the summer of 1947 and in the spring of 1948.

Forty-six species of mammals were recorded. Twelve (26.7%) of these species are widely distributed in North America. Fourteen (31.1%) are widely distributed in the biotic provinces of western North America. Twelve (26.7%) have their centers of distribution in several biotic provinces of Mexico and range into our region from the south. Five (11.1%) are largely restricted to the Chihuahuan biotic province. Two (4.4%) have their centers of distribution in the Great Plains.

The region studied is believed to include parts of two biotic districts. The Rio Grande Basin district includes the old Rio Grande Basin and differs from the Sierra Vieja district in ecological associations and in its vertebrate fauna. The Sierra Vieja district includes the Sierra Vieja mountain mass, at least east of the summit, and the adjacent Valentine plain.

Two life belts are recognized in the Sierra Vieja district. Thirteen species of mammals occur in one or more of the seven ecological associations of the Plains belt but not in the Roughland belt. Twenty-three species occur in one or more of the six associations of the Roughland belt, but they do not extend out into the Plains belt beyond the transitional catclaw-cedar association. Nine species occur in both life belts. One species is restricted in our area to the Rio Grande Basin district.

Differences in climate, in elevation, in ecological associations and in the vertebrate fauna distinguish the Sierra Vieja district from the Davis Mountain district to the east. Somewhat similar differences exist between the Sierra Vieja district and the area of the Chisos mountains to the southeast.

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PENICILLIN AND STREPTOMYCIN SENSITIVITY OF SOME PROTOZOA

John B. Loefer
Foundation of Applied Research
San Antonio, Texas

Antibiotics have provided a useful tool for obtaining bacteria-free cultures of protozoa. A number of investigators have employed them to obtain pure cultures of such species as **Trichomonas foetus, T. vaginalis, Colpidium campylum** and **Endamoeba.** There is, however, little information regarding the effect of antibiotics on metabolism of protozoa. It is generally known that they inhibit bacteria in fairly low concentrations. It is known that yeasts and spermatazoa have high tolerance for penicillin. Our knowledge of their action on protozoa however, is very meager. It is not known what concentrations inhibit growth, motility, or interfere with other manifestations of metabolism. It is not known whether certain levels depress division rate, nor do we know how different species are affected by various concentrations of different antibiotics.

Experiments were set up to determine the effects of different concentrations of penicillin and streptomycin on motility and viability of **Tetrahymena geleii, Euglena proxima, Chlamydomonas pseudococcum and Chlorella paramecii.**

EXPERIMENTS WITH PENICILLIN

Cultures contained penicillin in concentrations ranging between 5,000 and 133,300 units/ml of penicillin for each of these species. Inoculations were made from actively dividing stocks and the cultures were incubated under constant light for periods varying from twenty-four hours to seventeen days. Data on motility and viability was recorded at successive intervals during the culture period. When motility was not evident, a viability test was made. The following table summarizes data obtained:

TABLE I. EFFECTS OF PENICILLIN ON MOTILITY AND VIABILITY

Species	Motility Range	Viability Limit
Tetrahymena geleii	10,000, below 25,000	10,000, below 25,000
Euglena proxima	75,000, below 100,000	133,300 or above (4 days)
Chlamydomonas pseudococcum	—	75,000, below 100,000 (7 da.)
	—	below 25,000 (17 days)
Chlorella paramecii	—	below 25,000 (7 days)

The results indicate that the species tested vary greatly in their response to different concentrations of penicillin. **Euglena proxima** remains motile in concentrations as high as 25,000 units/ml and is viable after exposure to 133,000 for four days. The ciliate **Tetrahymena** was non-motile after exposure to 25,000 units. The same was true for **Chlorella. Chlamydomonas,** however, was viable after seven days exposure to 75,000 units.

EFFECT OF STREPTOMYCIN

Streptomycin was similarly tested on **T. geleii, E. proxima** and **Chlorogonium tetragamum.** The ciliate multiplied in concentrations up to 20 mgm/ml. The growth was somewhat retarded as compared with controls. Acclimatizing the stock culture by allowing it to grow for several days with 10 mgm/ml of streptomycin appeared to have no effect on the upper limit of motility or viability. **Chlorogonium,** after several days exposure to a concentration of 20 mgm/ml, is not viable. **Euglena proxima** behaves quite differently from the other species tested in that it was viable after twelve days exposure to a concentration of 100 mgm/ml, although it was not motile in the 50 mgm/ml concentration. Another striking fact observed in connection with this species is that chlorophyll formation was inhibited in cultures containing as little as 5 mgm/ml of streptomycin. In concentrations ranging from 5 to 15 mgm/ml, growth was very good and no significant retardation was noted as compared with controls.

Experiments are being made to determine the effect of other antibiotics on both free-living and parasitic protozoa.

CANCER OF THE HUMAN GENITAL ORGANS FROM THE STANDPOINT OF ABNORMAL STEROID METABOLISM

Max N. Huffman
Department of Biochemistry
Southwestern Medical College

There no longer remains doubt that the steroid sex hormones are concerned in the etiology of cancer of the reproductive organs. Just how they fit into the etiological picture is not known; and it is not the purpose here to discuss whether steroid hormones should be regarded as remote causative factors or as more nearly proximate causative factors, or whether they act interdependently with other tumorigenic agents.

In general, there are two important views concerning the induction of cancer by steroid hormones. One theory holds that an over-supply of hormone is responsible; the other theory maintains that the causative agent is an abnormal steroid metabolite more tumorigenic in nature than the known hormone. The author has for several years been associated with the latter view, and has, since 1941, been engaged in the synthesis of steroid compounds which might logically be regarded as metabolites.

Our present knowledge of the metabolism of the steroid hormones is far from complete. However, it is clearly recognized that in the estrogen series the hormones estrone and alpha-estradiol exist in biochemically reversible equilibrium; furthermore, one of these two estrogens (probably estrone) is catabolized irreversibly to estriol in the human organism. In the transformation of estrone to estriol there exists the possibility of four stereoisomers of the 16, 17-glycol possessing the unchanged estratriene nucleus. Three of the possible four isomers have now been prepared in pure form. The author and his associates have adopted a method of synthesis of 16, 17-dihydroxysteroids which leads from the 17-ketosteroid through the 16, 17-diketone and thence through the 16, 17-ketol. Through this synthetic route the same series of Ring D substituted steroids has now been prepared with the androgen nucleus. A question arises whether 16, 17-diketosteroids and 16, 17-ketolic steroids are not themselves to be regarded as abnormal metabolites.

In recent years degradative studies on the steroid hormones have established the astonishing fact that opening of steroid Ring D may lead to compounds of powerful biological activity. We have therefore submitted a 16, 17-diketosteroid to synthetic operations which rupture the C_{16}-C_{17} bond with production of an aldehyde group and a carboxylic acid group. Such a compound has then been reduced to the hydroxy acid which in turn spontaneously lactonizes to give the alpha-lactone. This series of reactions has been performed upon such hormones as estrone, androsterone, dehydroisoandrosterone, etc.

The concept of biochemical antagonism has altered the approach to the study of tumorigenesis from the standpoint of abnormal steroid metabolism. For instance, administration of estrogen often brings about strikingly beneficial results in clinical cancer of the prostate. While this phenomenon is generally regarded as being due to the anti-androgenic action of estrogenic substance in which the physiological effect of male sex hormone is opposed by the physiological effect of female sex hormone, it is possible to interpret this antagonism in a somewhat different light. Let us suppose that the pertinent causative factor in cancer of the prostate is an abnormal androgen metabolite: then estrogenic substance may be regarded, because of structural similarity, as competing against this abnormal androgen metabolite in a specific biochemical reaction. Perhaps, however, estrodiol or stilbestrol are not very efficient competitors in this particular biochemical reaction. Perhaps a much better competitor or biochemical antagonist can be found. Again, let us suppose that the endocrine factor in cancer of the breast is an abnormal metabolite of an estronegic hormone: then testosterone, because of structural similarity, competes against this metabolite in a certain biochemical reaction. Perhaps, however, testosterone is not a completely biochemical antagonist; perhaps a more efficient inhibitor can be discovered or invented.

In the concept of induction of cancer by an abnormal steroid metabolite it is not necessary to assume that the metabolite has hormonal activity to any considerable degree. Neither is it necessary to assume that the most effective biochemical antagonist has hormonal activity. That hormonal activity and tumorigenic activity parallel each other is, in our opinion, unlikely. Although it is clearly recognized that the most effective competitive inhibitor need not be a member of the opposite sex hormone series, our thinking has largely been in this direction because of the unique structural specificity of the steroid hormones.

Abstracts

FIBER PLANTS OF THE BIG BEND AREA OF TEXAS. Omer E. Sperry, Department of Range and Forestry, A. & M. College of Texas. (Abstract)—This paper deals with the taxonomic, economic and into the following three families: Liliaceae, Amaryllidaceae and Bromeliceae. Five genera are included. These are: Yucca, Nolina, Dasylirion, Agave and Hechtia. The leaves of all of these plants produce more or less fiber, and most of them have been exploited by some generation of peoples. A number of the species here discussd also produce considerable fiber in the stems. Indian basketry and cordage uses, as uncovered by investigators, bear evidence that most of the Big Bend fiber plants were utilized. Some of the species, as shown by recent investigations, produce up to forty-five percent of the dry weight of the leaf in fiber.

Some of our fiber plants produce forage or emergency livestock rations, others contribute to dwelling construction, and all play an

important role in soil conservation. In heavily grazed areas it is often noted that the only normal plants of the more palatable grasses and forbs are growing in the protection of the larger plants that were not grazed. The source of seed of these palatable species is exceedingly important in their maintenance on the range. Two species included are toxic to livestock under certain conditions.

Since more than seven hundred thousand acres of the Big Bend Area are in the Big Bend National Park, the importance of many of these plants in adding color and interest to the Park Area cannot be overlooked. Many square miles of desert scrub surround the mountains included in the Park proper. The fiber plants, together with the cacti and other desert shrubs, do much to enliven the landscape for the tourist who must pass through these areas to reach the more scenic mountain and river sites.

CHANGES IN NATURAL VEGETATION IN PASTURES ON ABANDONED FARM LANDS IN BRAZOS COUNTY, TEXAS. Thad B. Trew, Department of Range and Forestry, A. & M. College of Texas. (Abstract)—This study was undertaken at the beginning of the growing season of 1947 to determine the changes in vegetation in pastures of formerly cultivated lands at various stages of abandonment. Fifteen areas in the vicinity of College Station, used as pastures after being abandoned as farm land, were selected for this study. These areas had been abandoned from growing crops from one to twenty-seven years. All pastures were grazed at various intensities, and although three were terraced, none were fertilized. The vegetational analyses of the pastures were made using density and composition as the primary means of securing data.

A study of this nature is of considerable economic importance to farmers throughout East Texas, since thousands of acres of formerly cultivated land have been abandoned due to low fertility and economic situations. The average ranchman in the area is financially unable to develop improved pastures from worn out farm lands. The availability of seed, fertilizer and the high cost of labor are major reasons for allowing the native and adapted vegetation to take over the areas in the course of natural plant succession.

When the area is abandoned from cultivation, natural plant succession begins, and unless continually held back by grazing, there is a tendency for the areas to become a more or less stabilized grassland. If ample time is given for both plant and soil development, a climax vegetation may be reached. The successional units shown in these pastures are:

1. Annual weed stage
2. Annual grass and weed stage
3. Annual—perennial stage
4. Perennial—annual stage
5. Perennial stage

Grazing, and in most instances overgrazing, is the most important factor in keeping the composition of the pasture areas in a low level of successional development. Soil, proximity to natural seed sources, and former cultural practices are factors influencing development; but grazing plays such an important and modifying role that these become of secondary consideration. It is natural that perennial grasses should dominate the area as they are more adapted to compete for water and soil nutrients than the shallow rooted annuals.

A COMPACT SENSITOMETER WITH EXPOSURE RANGE OF 1 TO 10,000. Anthony D. Grover. (Abstract)—A sensitometer is described which produces 40 exposure areas 11.2 mm. in diameter over a range of intensities from 1 to 10,000 by combining the principle of an absorbing medium to that of fixed aperatures as employed in the obsolete tube sensitometer. The instrument is portable, uses 5 x 7 in. cut sheet film or plates and can be used with any light source including sun light. All the forty exposures are produced simultaneously and any exposure interval may be employed from a fraction of a second to many hours.

COLONEL JARED ELLISON GROCE, THE FATHER OF TEXAS AGRICULTURE. Col. M. L. Crimmins, San Antonio, Texas. (Abstract)—The foundation for the backbone of Texas prosperity, as well as founding the power that was doomed to sway the destiny of Texas is COTTON—the leading cash crop of our State. Texas has her cattle, corn, timber, sulphur, gas and oil, but cotton is still KING. The man responsible for the introduction of cotton was Colonel Jared Ellison Groce, who came to Texas early in 1822 with a large caravan of 116 slaves and fifty wagons, with horses, mules, cattle, sheep, and hogs to develop East Texas. He settled on the east bank of the Brazos four miles below what is now Hempstead, and eventually had, it is said, all the "walking land" in five counties adjoining—over 67,000 acres. Besides growing the first cotton in 1822, he established the first gin and in 1826 shipped 100 bales to New Orleans. He took an active part in suppressing the cannibalistic Karankawas in 1824, fed and foraged Sam Houston's Army for two weeks so as to fit them for their victory ten days later at San Jacinto. The Declaration of Texas Independence was written at his home, "Groce Retreat." His son, Leonard W. Groce, of "Liendo" carried on the program which his illustrious father instigated and in addition to farm crops, he grew over 500 varieties of plants and shrubs and many useful trees. He won the silver cup for the first five bales of cotton in 1842, and the gold cup for the first twenty given by a committee of merchants in Houston.

FORAGE COMPETITION BETWEEN THE PRONGHORNED ANTELOPE AND DOMESTIC SHEEP IN TRANS-PECOS TEXAS. Helmut K. Buechner, Texas Cooperative Wildlife Unit, College Station, Texas. (Abstract)—The purpose of this paper is to point out the probable cause for the incompatibility between the pronghorned antelope and domestic sheep. While competition between these two animals has been recognized for the past decade or so, little has been done to determine the cause and effect relationships involved. On the basis of 60 clip quadrats on three ranches representing different types of livestock grazing, it is shown that sheep are responsible for eliminating forbs and grasses when the range is overstocked. Since forbs constitute the bulk of the antelope diet, populations of antelope are limited by the amount of forb forage remaining on the range under utilization by sheep.

ON THE MECHANICS OF THE AFRICAN SPITTING COBRAS, NAJA NIGRICOLLIS AND HEMACHATUS HAEMACHATUS. C. W. Horton, The University of Texas. (Abstract)—In South Africa there are two genera of the cobras which enjoy a modification of their fang structure that enables them to eject their poison into the eyes of other animals. According to Ditmars, the snakes can eject their poison a maximum distance of 12 feet. A simple calculation based on this figure shows that the venom must have a velocity of 600 cm/sec when it leaves the fangs. An application of Bernoulli's theorem shows that the pressure in the poison glands necessary to produce this velocity is 180,000 dynes/cm^2. A correction for the viscous losses in the fang increases this figure to 270,000 dynes/cm^2.

If it is assumed that the poison sack has a circular cross section and that the walls of the masseter muscle have a thickness of one-tenth the radius of the gland's cross section, it is easy to show that the tension that must be developed in the masseter muscles is 1,350,000 dynes/cm^2.

PRECIPITATION OF COPPER HYDROXIDE IN PRESENCE OF SULFOSALICYLIC ACID. Stanley E. Turner and Robbin C. Anderson. (Abstract)—An investigation is being made of the effect of complex ion formation with sulfosalicylic acid upon the precipitation of certain ions such as those of copper, calcium, magnesium and iron. In the present series of experiments, precipitation of copper hydroxide is being studied.

A technique based on pH variations is used to determine conditions for first formation of precipitate. The presence of sulfosalicylic acid affects the ease and extent of precipitation. Color changes show that complex ions are formed; so that the sulfosalicylic acid reacts to tie up cupric ions in complexes and thus to interfere with reaction with hydroxide.

Spectrophotometric studies show that two different complexes are formed—possibly involving different combining ratios of sulfosalicylate ions to cupric ions or a complex of copper and hydroxide. Studies of the nature of these complexes are being made.

The pH determinations and spectrophotometric measurements of complex concentrations are being combined in precipitation experiments to obtain quantitative data on extent and mechanism of the influence of the complexes on copper hydroxide formation.

THE CONSERVATION OF MAN AND HIS RESOURCES. John G. Sinclair, Medical Branch, University of Texas, Galveston. (Abstract)—The Texas Academy of Science is establishing a Conservation Council of twelve members and a president. The object of the Council is to publish studies by its members and their cocouncillors dealing with the following range of subjects. 1. The physical and mental health of the people of Texas. 2. Genetic composition, eugenic and dysgenic practices. 3. Social and economic factors affecting living standards. 4. Ground water, rivers, lakes and water power resources. 5. Soil erosion and composition in relation to agriculture. 6. Forest and grassland resources. 7. Petroleum and gas resources. 8. Minerals in general and source materials for atomic energy. 9. Marine resources. 10. Wild life, refuges. 11. State parks, monuments and recreational centers. 12. Collections from archeological and paleontological sites.

The presidential address deals particularly with the first six of these topics.

SCIENTIFIC ACADEMIES. Chauncey D. Leake, Vice-President, University of Texas Medical Branch, Galveston. (Abstract)—Although scientific acedemies take their origin from the Athenian grove where Plato taught, modern scientific societies began with the chartering in London in 1662 of the Royal Society for the Improving of Natural Knowledge. Secretary Henry Oldenburgh's correspondence with interested scientists throughout the world became so great that the letters began to be published in journal form. This resulted in the famous **Philosophical Transactions of the Royal Society of London.** Since 1665 these have been largely responsible for maintaining the prestige of the organization. Similar societies were later established in Paris and in other European countries. The American Philosophical Society was organized in Philadelphia in 1743, for the promotion of useful knowledge, and its **Transactions** have appeared since 1769. Specialized scientific societies began to be established toward the latter part of the 18th century. The British Association for the Advancement of Science was organized in 1822, and the American Association for the Advancement of Science was founded in 1848. The Western Academy of Natural Sciences started by Daniel Drake in Cincinnati in 1833 was the first such organization west of Philadelphia. The Texas Academy of Science was established in 1880, but with no publications, stopped functioning in 1887. A second Texas Academy of Science was organized in 1892, and was active until 1912, having published twelve volumes of **Transactions.** The present Texas State Academy of Science was organized in 1929. Its permanence may depend on the regular publication of its **Transactions.**

The function of an Academy of Science is to stimulate scientific progress generally through opportunities for exchange of scientific information and opinion among representatives of all the various sciences. A regional Academy of Science has an added obligation in promoting the vigorous scientific study of problems arising from or peculiar to the region. Texas is still an intellectual frontier. Its problems are manifold, not only in the devolpment and conservation of its enormous natural resources, but also in the promotion of the full scientific capacities of its remarkably varied and enthusiastic people.

THE ELEMENTARY DYNAMICS OF TERRESTRIAL AND LUNAR IMPACTS. John D. Boon. (Abstract)—The impact of a large, swiftly moving meteorite is a problem of dynamics and should be considered from this viewpoint. In this study certain physical laws, principles, and processes are applicable. About twenty of these factors are listed. From these factors the following conclusions seem to be logical:

(1) Even the most rigid solid may behave as a liquid if it is sub-

jected to the pressure created by the impact of a meteorite. (2) When an impact takes place the kinetic energy is almost instantly changed into other forms. (3) The energy absorbers that work the more rapidly will get the greater portion of this energy. (4) Heat is a slow energy absorber, hence but little impact energy is transformed into this form. (5) The only place where high temperatures are produced is at the interfacial contacts. (6) Terrestrial meteorite craters should be quite different in form from lunar meteorite craters, because the latter body is, in general, more elastic than the former.

THE THEORY OF DUAL ROTATION. George L. Edwards, Brownsville, Texas. (Abstract)—The theory of dual rotation is offered as a logical explanation of geological sequences, including the alternate submergence and emergence of the continent and the necessity for such a process. The slow shift of the lithosphere to different climatic zones during each geologic cycle brings about the so-called Ice Age in one phase of rotation and submerges the continent in the equatorial bulge in the other. This movement also accounts for tropical and subtropical flora fossils as well as coal deposits within the Arctic Circle.

Comment will be made on the International Latitude Service and its reports covering forty years of observation at five observatories located several thousand miles apart, together with changing coast lines and other circumstances which led to locating the center of this secondary movement at the Magnetic North Pole.

The location of the Magnetic North Pole, its reported ability to move about, the effect of slow rotation about that center, earth magnetism, solar radiation, climatic zones permanently fixed by the solar system, earth's climate past and present, and maximum variation in latitude brought about by this secondary movement will also be discussed.

Commenting on rotation of the earth about its solar axis, I will briefly refer to centripetal energy generated by rotation which has created the equatorial bulge and formed the earth into an oblate ellipsoid. The effect caused by this bulge, which increases the distance from center of the earth to sea level approximately 765 feet for each degree as we approach the equator. Ability of the hydrosphere to adjust its particles so as to form the contour of the bulge in response to increasing centrifugal force as it slowly moves toward the equator. Inability of the land to form the contour of the bulge, resulting in extreme tensional stress, faulting with accompanying earthquakes, rifts, upthrusts, geosyclines and submergence. In the other phase of this secondary rotation, the lithosphere moves away from the equator, land emerges, centrifugal force lessens, tensional stress gives way to compressive stress which results in faulting, folding and major mountain building.

In the proper place, I will briefly discuss erosion while land is emergent and rejuvenation by sediment while submerged diastrophism brought about by this secondary movement and the Orogenic Cycle which starts with a geosyncline formed during some previous phase of tensional stress and ends with a major uplift during a later phase of compressive stress.

A METHOD FOR VERIFYING THE LAWS OF DEFINITE PROPORTIONS AND OF MULTIPLE PROPORTIONS. B. E. Schulze, Corpus Christi Junior College, Corpus Christi, Texas. (Abstract)—A method of verifying the laws of definite proportions and of multiple proportions is described. The method is not new but is a modification of a method found in several manuals currently used in freshman chemistry classes.

Potassium chlorate and potassium perchlorate each of C. P. grade are decomposed in the presence of a catalyst. A specially prepared stopper is used to prevent the loss of any material except the oxygen. The weight of oxygen combined with one gram of potassium chloride in each compound is determined. The ratio of the weights of oxygen obtained agrees within one percent or less with the theoretical value.

Other advantages of the method: (1) Inexpensive triple beam balances are used. (2) The entire experiment can be performed in one three hour laboratory period.

MORPHOLOGICAL AND UTILIZATION STUDIES ON PRAIRIE THREE AWN GRASS IN BRAZOS COUNTY, TEXAS. Alfred H. Walker, A. & M. College.—(Abstract)—One of the most widespread and abundant annual grasses of the central and eastern United States is prairie three awn grass, **Aristida cligantha Michx.** The local preponderance of this grass denotes range misuse in this area since the bluestems and post oaks are the climax vegetation. Due to the abundance of this species the growth habits, forage value, effect of grazing and palatability are of major economic importance. A detailed study concerning these essential points was conducted from November, 1946, to September, 1947. The following conclusions are indicated:

1. Prairie tree awn grass exhibits most of the characteristics common to the other grasses of this genus. Significant differences which differentiate it from other species of **Aristida** are the long divergent unequal awns, annual root system, lanate base, and glabrous sheath.

2. The outstanding characteristics for identifying prairie three awn grass in the various growth stages follow:

a. Winter stage—Short pedicels and long glumes.
b. Seedling stage—Attached seed parts and geniculate base.
c. Boot stage—Lanate base, glabrous sheath, and pilose blade.
d. Early flower stage—Flattened nodes, long internodes, and lanate base.
e. Mature stage—Long divergent unequal awns and lanate base.

3. Roadsides, fields retired from cultivation, and overgrazed ranges are the natural habitat for prairie three awn grass. Raising soil fertility in such areas results in increased size and forage production of plants and replacement of this species by more desirable types of vegetation.

4. Prairie three awn grass normally germinates in February, makes abundant growth in early spring and summer, and produces seed in August and September.

5. **Aristida intermedia** Scribn, and Ball produces less forage and commonly grows on less fertile soils than prairie three awn grass. Characteristics which differentiate these species are the short spikelets and awns (less than 1 inch long) and smooth base on **A. intermedia.**

6. Heavy fall grazing of prairie three awn ranges results in lowered forage production the following season.

7. Burning of prairie three awn ranges in the fall is a detrimental practice. Forage production is decreased about 75 per cent and range deterioration occurs the next season.

8. Clipping studies at various growth stages reveal that forage production is increased by clipping and the forage remains more palatable. Mortality of plants increased with the number of clippings, but season-long observations indicate about twice as much forage production on clipped plots as on ungrazed plots.

9. The maximum forage growth occurred on plants first clipped in the late boot stage. Plants clipped at 1 inch produced six times the height forage growth when compared to ungrazed plots and clipping at 2 inches produced over four times as much forage by the same comparison. Prairie three awn has become so coarse and wiry by this stage if previously ungrazed that it is largely unpalatable to livestock. Therefore, grazing must be initiated earlier in the season to secure maximum utilization.

10. Prairie three awn grass makes up a large portion of the forage utilized by livestock in this locality. This grass is low in palatability and usually is the last grass grazed in a pasture of mixed grasses. There is a reciprocal relationship between range condition class and the degree of utilization of prairie three awn.

11. Rotation heavy grazing of pastures and range land supporting moderate to heavy stands of prairie three awn grass is recommended. Cattle should be grazed on these areas from mid-April to mid-August permitting plant residue and seed formation to contribtue toward range improvement. Further research into the economics of fertilizing and reseeding poor-condition ranges for more rapid range improvement is suggested.

PAIN AND THE ASPHYXIA OF NERVE—E. P. Porter and J. L. Coleman, Department of Physiology, University of Texas, School of Medicine. (Abstract)—When the blood supply to a tissue is interfered with pain often results. This is particularly true in the limbs following obstruction of the blood vessels by a clot or by arterio sclerosis, and in the heart when the agonizing pain of angina pectoris occurs. It is still a question as to just what causes the pain. It has been suggested that the products of metabolism stimulate the pain nerves but there is also the possibility that the nerve itself is affected by the asphyxia. Porter and Wharton (Journal of Neuro-Physiology, in press) found that a mammalian motor nerve becomes more irritable when its blood supply is cut off. This present report has to do with a sensory nerve. We have located a place in the hind leg of the cat where it is possible to cut off the blood supply from a pain nerve and study the effect. The experiment is done on the spinal (headless) cat, which can suffer no conscious pain but still withdraws the foot to a painful stimulus just as the conscious animal would do. In this preparation a weak shock through the pain nerve will cause a slight movement of the hind leg. If now the blood supply to the nerve which is receiving the shock is cut off, the movement of the leg becomes much more vigorous. Returning the blood to the nerve brings back contractions to their original height. This indicates that a pain nerve, like the motor nerves, become more irritable when it lacks its normal blood supply. This increased irritability may play a part in producing pain in the human patient when the blood flow is obstructed.

SOME BIOCHEMICAL ASPECTS OF SEX DETERMINATION IN BONELLIA VIRIDIS—Wiktor W. Nowinski, Tissue Culture Laboratory, University of Texas Medical Branch. (Abstract)—**Bonellia viridis** is a marine worm which belongs to the class of Echiurida. The female possesses a trunk of the shape and size of a walnut, and a contractile proboscis which, when stretched, can be as long as 1 yard. The male is about 1/16 inch long, has an aspect of a nematode, and lives as a parasite in the intestines (foregut) and the uterus of the female. From the laid eggs, sexually indifferent larvae develop: those which fix on the proboscis of the female, develop after 100 hours of parasitism, into males, those, however, which live free in water become females. Extracts from the proboscis and foregut of the female, when added to sea water, determine the sex of the larvae into the male. This shows that the female produces an active, sex determining substance. The extracts are insoluble in acetone, soluble in water and thermostabile. The sex determining substances act probably upon the genetic constitution of the larvae, by increasing the activity of MM-substances and thus outbalancing the slightly stronger FF substances in the sex determining chromosomes of the larvae.

INDIVIDUALITY IN NATURE. THE PSYCHOLOGIST'S VIEWPOINT. Glenn V. Ramsey, Professor of Psychology, University of Texas. (Abstract)—Psychology concerns itself as a science with the phenomena of behavior. The descriptive and objective studies of behavior have repeatedly demonstrated the universality of individual differences. The psychologist is continually concerned with the measurement and the interpretation of such differences.

In the past, psychological studies of individuality in behavior have been primarily based on measurements of specific or segmental traits such as seen in the studies of sensory and motor reactions, learning, and conditioning. Also the studies in the field of personality have been largely concerned with the investigation of specific aptitudes, interests, types of intelligence, and traits such as introversion-extroversion, dominance and submission, etc. Practically all trait studies have provided data which illustrate the individuality of behavior.

In recent years, psychologists have become more concerned with the measurement of central or integrative processes, in contrast to their former interests in segmental or specific trait studies. This shift has brought into focus the "global" or "holistic" characteristics of organismic behavior and the dynamic nature of behavior. While the older trait studies revealed information concerning individuality, the newer approach has produced data which give even a greater emphasis to the importance of individuality. The older trait measurements lose much of their significance when viewed in light of the total behavioral configurations. The complexity and individuality of behavioral patterns or characteristics become much more apparent in the newer approach. It is now evident that individuality demands a position of greater importance than it did in the past.

Trait measurements led psychological investigators to seek for generalities. The newer dynamic studies of behavior have challenged the search for communalities and have in turn called attention to the individuality in psychological phenomena. The increasing importance of individuality adds to the complexity of behavioral investigations, but leads to a more fundamental understanding of behavior.

THE LIFE OF CELLS IN VITRO. C. M. Pomerat, Tissue Culture Laboratory, University of Texas Medical Branch. (Abstract)—The importance of Carrel's demonstration that cells cultured **in vitro** establish beyond question the "immortality" of cells was re-emphasized. Work by Earle and his co-workers demonstrates the method for the cultivation of a clone from a single cell. This group has also developed mass culture techniques using cellophane which permits more refined biochemical studies on genetically homogenous materials.

Recent observations on the lung of a three month old human fetus revealed that, whereas growth at 37°C for 30 days resulted in a pattern consisting entirely of spindle cells, corresponding cultures at room temperature showed persistence of epithelial organization. In both instances bronchial aborizations with attached and isolated terminal buds could be seen. At body temperature, however, the pattern was one of skeletogenous organization whereas at room temperature the pattern was made up of closely packed cells which could be shown to have the characteristics of cuboidal form in the bronchial ducts and a squamous pattern in the terminal buds.

INDIVIDUALITY IN NATURE. BIOCHEMISTRY. Roger J. Williams. (Abstract)—Morphological inheritance is well known and commonplace, the inheritance of distinctive metabolic features has received little attention.

The individuality which exists with respect to the detailed mechanisms for carrying out metabolic transformations is no mere curiosity or philosophical plaything but is something which vitally influences our lives in many ways.

It is probably safe to say that most if not all drugs have as a basis for their physiological action their influence upon, and often interference with, the functioning of specific metabolic transformations. If we all had the same metabolic machinery, drugs would affect us all alike, but they do not.

One of the agents in which we have become interested from this standpoint is alcohol. We are convinced that the variable effects of this substance on different people, particularly the development of an intense craving which constitutes the core of the alcoholism problem, is based to a considerable degree on the distinctive metabolism which each person possesses.

The recent interest in Buerger's disease due to the afflication of the British monarch is another case in point. The evidence that Buerger's disease is brought on by the use of tobacco is very strong, and indidentally, its incidence among women is increasing rapidly. It is a relatively rare disease, however, because we do not all have the same metabolic machinery and we are not all affected by tobacco in the same way.

These are but illustrations of how metabolic individuality is important. It is also believed to be important with respect to mental disease and in relation to the mental abilities and behavior patterns of individuals. Metabolic patterns need to be studied in relationship to **each** of the numerous problems in which they are important factors.

HOLMES THE SCIENTIFIC WRITER. Leona Meissner, Science Club, McMurray College. (Abstract)—This paper endeavors to show the importance of Holmes's distinctive medical work and his scientific explorations. He gave the best years of his life as a teacher of physiology and anatomy.

His professional writings reveal that he is "a sinewy and aggressive fighter, conscious of his strength, proud of the great scientific spirit he represented, exulting in his polemical cunning." He was a master of style in whose phrasing there is no technical flaw.

In the years 1836 and 1837 Holmes won three of the four Boylston prizes with three of his essays. The essay on intermittent fever is still important and interesting as is the one on "The Utility and Importance of Direct Exploration in Medical Practice."

Most famous, although unrecognized during his time, is his paper on puerperal fever, in which he recognized that it could be prevented by the use of antiseptics.

His most influential work was an address on "Currents and Counter-Currents in Medical Science" in which he spoke against the use of excessive drugs. He emphasized the fact that to cure a patient means to take care of him until his natural strength could overcome his ailment.

Holmes was the author of three little read medical novels. A recent study by Dr. Clarence P. Oberndorf, clinical professor of psychiatry at Columbia University, showed that in them Holmes expressed many important concepts of psychoanalysis some fifty years before Sigmund Freud.

Holmes has truly been called "the most eminent American contributor to preventive medicine of his day." A bibliography of thirty-seven sources bearing directly upon the central theme is given.

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Population problems. Net reproductive rate and controls.
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Soil and water conservation especially in relation to crops.
Paul Walser, Soil Conservation Service, Temple, Texas
Animals adapted to Texas agriculture. ....
Plants adapted to Texas agriculture. ....
Marine resources.
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FOREWORD

You will note that some changes have been made in the format of this issue, which is Number 2 of Volume I. Headings have been placed on all of the pages and abstracts, and bibliographies are in smaller type to save space for papers themselves. The Editorial Board will be glad to have your reaction on this as we wish to make this your Journal and to make it serve you as well as we possibly can.

It will interest all of you, we are sure, to know that with Volume I, Number 3, which will be issued September 30, what we hope will be the permanent format of the Journal will be attained. We have worked out with the printer a form of type somewhat different from that in the first two issues, which will allow us to use italics instead of black face and which we feel will make it possible for us to present a more attractive Journal.

We are badly in need, however, of one or two good papers, well illustrated, on topics of general interest, somewhat after the type used in Scientific Monthly. Any such paper will receive our most careful consideration.

The Editor.

Texas Journal of Science

Vol. I June 30, 1949 No. 2

CHEMURGIC CROPS FOR INDUSTRY

Victor H. Schoffelmayer
Southwest Research Institute
Dallas, Texas

Scientific research in recent years has made notable contributions to the industrial use of crops and crop wastes. This type of research, chiefly conducted for many years by forward-looking scientists of a few state and private experiment stations, more recently has had the benefit of four, large, well equipped regional research laboratories under direction of the U. S. Department of Agriculture. These four regional laboratories are located as follows:

Northern—Peoria, Illinois; Southern—New Orleans, La.; Eastern—Philadelphia; Western—Albany, California.

Each does a special type of research originally specified from Washington. More recently, however, the scope of this research has been greatly widened to meet steadily increasing needs not only of the various regions but of the nation as a whole.

Our state experiment stations in the meantime have enlarged their agricultural research, perhaps because of the keen competition set up on a regional basis.

Also, a number of large privately financed research institutions have come into existence, either endowed by enlightened men of wealth, or supported by progressive business men, bankers, land owners and others. The net result is highly important to our Texas region.

TEXAS AN EMPIRE

Because of Texas' vast size, vast spaces suited to the production of crops, forests and animals, and its great range of climatic conditions and soil types, it virtually amounts to an empire capable of producing perhaps the largest array of agricultural raw materials of any state.

Gradually there has been a trend away from cotton, which dominated Texas farming operations for most of a century. Crop diversification has been hastened as a result of the general introduction of some 230,000 farm tractors, 35,000 grain harvester-combines, 7,000 mechanical cotton harvesters and pickers, and a formidable array of multi-row tilling equipment which has virtually caused the disappearance of the horse and mule over large areas.

As the trend continues towards the raising of mechanically harvested crops, such as the sorghum grains, flax, rice, winter wheat, oil seeds and others, larger percentages of crops formerly wholly fed to livestock now are diverted to industrial use.

A notable example of this significant change in the Texas agricultural economy is the astonishing inroads of milo (a grain sorghum) into what only twenty years ago was almost wholly a cotton territory in a number of counties along the Texas Gulf Coast around Corpus Christi.

As a result of this remarkable change a large Eastern processing industry—Corn Products Refining Company—is completing a $20,000,000 plant near Corpus Christi to process millions of bushels of milo into industrial starches, dextrose syrup and sugar, and vegetable oils. This up till now is the largest single example of chemurgic use of a former livestock feed material on a commercial scale. It, however, is merely the beginning of this new trend.

Again it is important to state that, without the benefit of scientific research and breeding of low-headed grain sorghum types, there doubtless would not have developed such a huge agro-industrial project in Texas.

Let us stop to reflect a moment right here as to the nature of all crops and their possible destiny in our complicated modern economy.

All plants are largely a composite of carbohydrates, protein and minerals. Most of these raw materials come from the atmosphere—air, water and sunshine. Solar energy transmutes carbon dioxide and moisture into plant structure which man for centuries has used as food and fiber.

Modern chemical research has made possible the conversion of these former food and feed materials into needed articles of industry—plastics, technical oils, industrial starches and adhesives, ethyl alcohol and acetic acid (upon which a vast industry could be established) resins and gums, paper, rayon, aromatics, essences, detergents and many others.

NEW CHEMURGIC USES

As we go deeper into the chemical era and into the vast field of physics we begin to realize that from our crops and our forests will come increasing quantities of industrial materials to replace fast waning supplies of iron, steel, copper, lead, zinc, nickel and others.

Modern research has produced chemically treated wood virtually equal to mild steel in strength. A tree, through chemurgic treatment, can become a wide variety of papers from newsprint and kraft to those of the highest quality. Or it can become alpha cellulose which in turn is fashioned into ethyl cellulose, cellulose acetate or cellulose nitrate and spun into gossamer materials perhaps equal to or superior to natural silk, linen or cotton.

If we stop to consider, in a ton of sawdust (piled high around our thousands of lumber mills in East Texas and other parts of America) there are 1,100 pounds of glucose sugar and 600 pounds of lignin, and that the sugar can be converted into 60 gallons of ethyl alcohol or motor fuel, or into 200 gallons of livestock syrup (practically equal to Cuban blackstrap molasses).

But what is even more fantastic—we could actually eat our trees—by converting the cellulose into sugars and taking advantage of atmospheric bacteria to transform these apparent waste materials into protein testing 52 per cent or much higher than either cottonseed meal or soybean flour. The Germans, Finns, Norwegians and Swedes turned waste sawdust into protein feed and food during World War II. We could do likewise if we ever need to.

USING CROP WASTES

We are gathered today in San Antonio, only a stone's throw from the rich Lower Rio Grande Valley with its wealth of crops and their gigantic wastes. That Valley is an important producer of citrus fruits, most of which are processed into juice. Since one-half of every grapefruit or orange is peel our processors and producers are confronted with a problem of waste disposal. We have learned how to dehydrate citrus peel into livestock feed to supplement corn and other feeds, but more recently we have discovered that there is valuable pectin in these peels, and pectin has a high market value and is in great demand as a new and popular chemurgic raw material of industry.

We can extract the pectin from the peel and still have an excellent livestock feed left. Similarly we should extract the essential oils in our orange and grapefruit peel and sell them as perfume bases.

One large Valley firm—Universal Colloid Company—for the last eight years has been making metallic pectinates to supply an ever-increasing demand by the pharmaceutical industry. Some 50,000,000 pounds of pectin are needed to supply various industrial needs. California and Washington and Oregon in the past largely supplied the demand with pectin extracted from their wastes of the apple and pear canning and dehydration industries. But a feed shortage on the Pacific Coast, due to the sensational population increase in that region, has diverted these apple and pear wastes (pomace) into livestock feed channels and our Magic Valley has a greater opportunity than ever to manfacture pectin.

You may ask what the outlets for pectin are. Pectin is used as an easily digested covering for phamaceuticals—pills, capsules—for coatings on gum drops and sticky candies in moist climates to give them flowability in coin-operated slot machines, as skins for sausage and numerous other foods, to keep out bacteria and air and with no disposal problem (since the cover becomes a digestible food).

Still other uses for pectin are in combination with such metals as zinc, copper, cobalt, iron as medicinals or as arresters of fungus attack or as flame-arresters when applied to draperies, walls, etc. Pectin is displacing various established synthetic plastics and resins because of its ease of application and quicker disposability in the case of food covers.

PECAN SHELL TANNIC ACID

Texas is a large producer of pecans. One-half of the pecan is shell, and therefore considered a waste. To the enlightened chemurgist, however, pecan shells are a gold mine. In Weatherford and in Lufkin two separate firms for several years have processed pecan shells. J. R. Fleming at Weatherford discovered that in those pecan shells piled up around the large pecan meat extracting plants, such as you see in San Antonio, Dallas, Houston, Memphis and other centers, contain about 6 per cent small fragments of meats. By crushing the shells he obtains what is considered as the country's finest perfume base oil. In the remaining shells there are 18 to 26 per cent of tannic acid which he now extracts and ships in tank cars to eastern leather and other industries. Finally he and the plant at Lufkin, operated by H. A. Wittliff, grind the shells into a fine flour used as an extender for Bakelite and other plastics. Here you have a perfect example of chemurgy at work in Texas. How many other crop and fruit wastes await similar industrial uses I leave to your imagination. We must learn that all crop and forest wastes are merely chemical raw materials in the hands of the wide awake processor. In many instances these converted wastes constitute the difference between an industry's profit and loss.

Let us turn to our vast cedar forests of Southwest Texas and the Edwards Plateau Region. In recent years a few enterprising processors have set up plants in the wilderness to extract various types of cedar oil and essence from the wood, the leaves and the berries. Several of these plants are operating around New Braunfels. Isn't that a lot better than to merely cut down our cedar trees and burn them on tens of thousands of acres because ranchmen want more grass for their cattle? Why not combine the two operations?

We could go on indefinitely. Let's turn to new chemurgic crops—safflower and sunflower seed, flaxseed and tungnuts as new sources of greately needed vegetable oils—paint, varnish and lacquer bases, almost entirely imported in the past. Why not grow them and add new, profitable crops to cur agriculture?

Why not essentials and aromatics from Dalmatian sage, Japanese mint, detergents from the roots of our wild yucca plants, tannic acid from another wild plant of the Southwest—canaigre—or waxes equal to imported Brazilian carnauba from the jojoba and the candelilla? There is one processor of candelilla wax in West Texas who ships it away by the millions of pounds a year. Why not grow this crop like sorghum or cotton?

We need to extend our research into these new chemurgic fields. We have neglected them in the past but we can not afford to neglect them in the future. We are running out of many materials which once were abundant but which are becoming scarce because of the terrific demands of a major war. Let's talk chemurgic crops for a change!

Let us also learn to use corn cobs and waste cottonseed burrs, now piled mountain-high around our West Texas gins, and obtain furfural from them to speed up our petroleum refining processes. Why depend upon Iowa for our furfural now made from oat hulls?

Then think of the many other wastes in such an area of canning and dehydration as the Lower Rio Grande Valley where supplemental processing industries can be erected alongside of the canning and juice extraction plants to make not only livestock feed but vitamins from waste carotene, and the chlorophyll in leaves and fruits and vegetables. Texas is ready for a new orientation in its agro-industrial economy, one which will bring agriculture and manufacturing into better balance with one another. These two are natural partners anyhow, but we need science and research to show us the way and give us the "know how."

PROFESSIONAL CHEMISTS IN TEXAS PRIOR TO 1920

E. P. SCHOCH
Bureau of Industrial Chemistry
University of Texas

This paper was primarily intended to be a history of Chemistry in Texas up to the present time. However, the rapid growth of the petroleum industry since 1920, and the still more rapid growth of the chemical industry in Texas since the war made this subject too large for the time available to prepare this paper. Hence it has been limited to the time prior to 1920.

Limitations of space also made it necessary to confine the list of names to those who were chemists by profession, although it is realized that many others have contributed to the science during this period.

There are likely to be many names omitted from this list who should be included; the writer will appreciate being furnished with information concerning such parties.

An asterisk at a name denotes that detailed biographical data concerning that name is found in AMERICAN MEN OF SCIENCE—and that this datum has been copied and is presented in the Appendix in alphabetical order.

CHEMISTRY AT AUSTIN COLLEGE—SHERMAN

The minutes of the Board of Trustees of Austin College of May 17, 1855 show the following interesting entry which indicates that Austin College was the first in Texas to teach chemistry. The quotation follows:

"Meeting in session at Huntsville, Texas, Be it resolved that Col. Henderson Yoakum be authorized to make a trip to the north to purchase such additional apparatus and chemicals as is deemed necessary for the science department of Austin College." Col. Yoakum was a veteran of the Mexican War under General Taylor, and at the close of the war he became a charter member of the Board of Trustees and the first secretary of the Board of Trustees of Austin College (1850 to 1855). He was a noted historian of Texas. Two of Col. Yoakum's colleagues who commissioned him to make this trip were Sam Houston and Anson Jones. Both had served as Presidents and later governors of Texas.

The minutes of the College show the heads of the Department of Chemistry of Austin College during its ninety-seven years of history as follows:

Professor Washington McCartney	Feb. 25, 1853 to June, 1853
Rev. A. E. Thom	June 29, 1853 to Dec. 1858
Professor B. F. Grady	June 22, 1859 to June 28, 1861
Professor Andrew T. McKinney	Sept. 3, 1862 to June 24, 1874
Professor W. D. Vinson	Sept. 3, 1878 to June, 1883
Professor J. C. Edmonds	June 13, 1883 to June 12, 1889
Professor C. C. Scott * D. Sci., Univ. of Heidelberg	June 12, 1889 to June, 1924
Professor B. F. Armendt B.A., M.A., Austin College Ph D., Univ. of Texas	June, 1924 to June, 1935
Professor Geo. L. Landolt * B.A., M.A., Austin College Ph. D., Univ. of Pittsburgh	June, 1935 to present

The present chemistry building was constructed in 1913. It is a three-story, fireproof structure, with laboratories and classrooms on each of the three floors. At the present time the biology department is housed in the chemistry building, but in a short time the biology department will be moved into new quarters nearing completion, releasing space that will be converted into general chemistry laboratories.

The present student body at Austin College is 586, of which 171 are taking chemistry. The departmental library is well equipped. Quite a number of Master's theses have been worked out in the two research laboratories, but at the present time no graduate work is being given in the department because of the large number of veterans who are doing undergraduate work in chemistry.

CHEMISTRY AT THE UNIVERSITY OF TEXAS

The first professor of chemistry at the University of Texas was Dr. J. W. Mallet, formerly Chief Chemist of the Confederate States. He came to the University of Texas in 1883, when it opened its doors for the first time. However, Dr. Mallet did not stay more than one session, but returned to the University of Virginia where he had been Professor of Chemistry previously, and where he remained for the rest of his life. He was succeeded in 1884 by Dr. Edgar Everhart,* who was professor of chemistry until June, 1894.

Dr. Everhart was an aggressive teacher and research worker. His enthusiasm enabled him to secure from the State Legislature an appropriation for a laboratory, in 1891, it being entirely overlooked at that time that such an appropriation is against a constitutional provision which prohibits the legislature from appropriating money for buildings for the University.

Dr. Everhart worked particularly on biochemical problems—one of his publications dealing with the composition and digestibility of human milk. After leaving the University, Dr. Everhart became Chemist of the Georgia Geological Survey where he remained until he passed away in 1937.

In 1894, Dr. Henry W. Harper * became Professor of Chemistry. In 1897, he was joined by Dr. James R. Bailey,* an organic chemist from Munich, Germany, and by the writer.* The latter two became professors in 1911. Research became the watchword of the laboratory, and many papers on organic, analytical and physical chemistry were published by both students and faculty members. It was not until 1919 that a further addition to the faculty was made; this was Dr. W. A. Felsing,* who then came in as assistant professor, and soon advanced to a full professorship. Dr. H. L. Lochte * joined the staff in 1922, and Dr. H. R. Henze * in 1926, but this takes us beyond the 1920 limit set for this paper. Dr. Bailey passed away in 1941, and Dr. Harper in 1943. Their fine characters and lofty ambitions left an indelible imprint not only on the writer, but on all who had been students under them.

All the chemistry teaching was given under the title "Department of Chemistry" until 1919 when the Department of Chemical Engineering was first created. In 1921, it was again merged with the Department of Chemistry because the attendance in chemical engineering then was too small to require separate administration; but by 1939 it had become so large that Chemical Engineering was again set up as a department of its own.

CHEMISTRY AT THE MEDICAL BRANCH OF THE UNIVERSITY OF TEXAS

Instruction in chemistry and toxicology was begun in 1891 at this school by Dr. Seth Morris. He equipped this department as well at that time as perhaps any such school was then equipped in the United States. In 1898 he was succeeded by Dr. A. I. Austin and the latter was succeeded by Dr. G. F. Gracey in 1910.

In 1913 Dr. William R. Rose joined the staff as professor of biological chemistry. He was succeeded—in 1922—by Dr. Byron M. Hendricks. Both Dr. Rose and Dr. Hendricks are well known for their many scientific contributions in this field.

Dr. Meyer Bodansky joined the staff in 1919, and remained there until his untimely death in 1942. During these years Dr. Bodansky rose to real eminence in his profession and his textbook on physiological chemistry was the leading text in the United States.

In 1921 Dr. H. R. Henze joined the staff of this department to devote himself to pharmaceutical chemistry. When, in 1926, the College of Pharmacy was moved to Austin, Dr. Henze then joined the faculty of the Department of Chemistry there, and his activities there are described in the notes above concerning this department.

Since 1920 the instruction in chemistry at the Galveston Medical School has expanded greatly, but this period of time extends beyond the time which this article is to cover.

CHEMISTRY AT THE A. & M. COLLEGE OF TEXAS

Professional chemistry may be said to have had its beginning at the A. & M. College of Texas with the appointment of H. H. Harrington, in 1888, as Professor of Chemistry. He was also State Chemist and Chemist of the Agricultural Experiment Station. He served in this capacity until 1905, when he became President of the A. & M. College. He did research work on the following subjects: the effect of feed stuffs on the nature of butter fat, the digestibility of feed-stuffs, the composition of certain plants, the chemical characteristics of the rice plant and the composition of Texas soils. Dr. Harrington was a high-minded man with an intense desire to help Texas agriculture. He was instrumental in the passage of the fertilizer law which required that every bit of fertilizer and insect poisons sold in Texas have to have a certificate issued by the State Experiment Station stating its composition.

When Dr. Harrington became president of the College in 1905, the chemistry work was divided. Dr. J. C. Blake * became Professor of Chemistry and Dr. G. S. Fraps * became State Chemist and Chemist to the Experiment Station. The Feed Control Law was passed in July, 1905, and this required the making of chemical analyses both for control purposes and to ascertain the composition of commercial feeds in order that suitable guarantees could be made. The first Feed Control report was published as Bulletin 90, in 1906, and reports containing analyses have been published almost every year since. The Feed Control Law was revised in 1907, amended in 1911 and 1917 and codified in 1925. The original feed law provided only for guarantees of protein and fat but the revised law required in addition, guarantees of crude fiber, nitrogen-free extract, and some other ingredients. Passage of the Adams Act in 1906 by Congress increased the chemical and other investigations of the Agricultural Experiment Station. The Agricultural Experiment Station building was erected in 1909 and occupied by the Division of Chemistry and all other Divisions of the Experiment Station. The Administration Building of the Agricultural Experiment Station building was erected in 1918 and the old building was renamed the Chemistry Research Building. A course in Chemical Engineering was established in 1909.

Dr. C. C. Hedges * was appointed Associate Professor of Chemistry in 1912 and became head of the department when J. C. Blake resigned in 1913. In 1919 M. K. Thornton Jr. joined the staff as Professor of Industrial Chemistry. The Department's name was changed to Chemistry and Chemical Engineering in 1908 and back to Department of Chemistry when a separate Department of Chemical Engineering was established in 1940. The Engineering Experiment Station was established in 1914. The chemical work, begun much later, deals chiefly with water supplies and purification of sewage. A new chemistry building, for teaching, was erected in 1929-1932.

In 1915, the Texas Cotton Seed Crushers Association installed a cottonseed oil mill at the College for instruction and research. The equipment has been added to from time to time since then. Research has been done on the time and temperature of cooking, the amount of water added, the destruction of gossypol, and other details affecting the manufacturing process and the quality of the product. A book "Cottonseed Products" was written by M. K. Thornton, Professor of Industrial Chemistry and published in 1932 by the Oil Mill Gazetteer, Wharton, Texas. Dr. C. S. Lyman, of the Swine Husbandry Division, has published work on the determination of gossypol in cottonseed meal, the preparation of cottonseed meal free from gossypol, and the determination of amino acids in feeds. Dr. P. P. Pearson, Nutritionist of the Division of Veterinary Science, has published articles on certain vitamin requirements of domestic animals.

An insecticide law administered jointly by the Commissioner of Agriculture at Austin and the State Chemist at College Station requires analyses of insecticides and fungicides. Circulars containing analyses and other information have been published in 1944 and 1945.

The outstanding figure of this period of chemistry at the A. & M. College of Texas is Dr. G. S. Fraps. He received a Ph. D. degree at the Johns Hopkins University in 1899, was an assistant chemist at the North Carolina Experiment Station till 1903, and since then he has been at the A. & M. College. In August, 1945, he retired to limited service status. His splendid service to the State, and achievements as a chemist are well expressed in the following quotation from the News Letter of August 15, 1945, issued by the Texas Agricultural Station:

"His broad and exact knowledge of the subject immediately impressed workers in other states and secured active cooperation from many of the nation's great chemists. Thus for more than 40 years, Dr. Fraps has been one of the leading spirits in the progress made in the knowledge of chemistry and its use in making the most of the whole agricultural enterprise. Many leading chemists have anchored their work to the bench marks established through Dr. Fraps' research. This forty-year period has witnessed amazing advances in chemical knowledge and especially in agricultural chemistry, and some of this progress is due to the orderly statements and methodical procedures developed by Dr. Fraps. Not only has he been a leading figure in the soils and fertilizer phases including the regulation of the manufacture and sale of commercial fertilizer but in the proper preparation and distribution of feeding stuffs and practical methods of evaluating the various feeding constitutents.

"As State Chemist, he has guided the formulation of helpful regulations to govern the distribution of fertilizers and the use of a limited number of grades and his administration of the fertilizer control law of Texas has been outstanding and epochal, serving as a guide to other states and as a helpful force for those engaged in the manufacture and sale of fertilizers."

CHEMISTRY AT TEXAS CHRISTIAN UNIVERSITY

Texas Christian University was founded in 1873 at Thorpe's Spring, Texas, with Randolph Clark as professor of science, but there is no definite record of the work covering the years up to 1887.

From 1887 to 1899 W. B. Parks, B.S., M.A. and Ph. D., T.C.U., was professor of science. In 1904, he returned to become professor of chemistry and physics, and served until 1916. From 1899 to 1904 the science instruction was given by C. M. Young, B.S. and from 1901 to 1904, by A. F. Armstrong, A.M.

Prominent among the later professors are:

F. W. Hogan, 1921—
J. L. Whitman, 1927-1945
F. M. Liste, M.A., 1943—
H. B. Hardt, Ph. D., 1946—

CHEMISTRY AT BAYLOR UNIVERSITY

Instruction in chemistry was begun at Baylor by Professor W. W. Battle in the fall of 1898. When, in 1911, Professor Battle became Director of the State Food and Dairy Commission, he was succeeded by Dr. E. Emmett Reid,* Ph. D., Johns Hopkins. The erection of the George W. Carroll Science Hall—largely devoted to chemistry—gave this subject the needed facility for growth at this school. In 1908, Professor Reid went to Johns Hopkins where he eventually became Professor of Organic Chemistry. He was succeeded at Baylor by Professor W. T. Gooch,* Ph. D., Chicago, who has been in charge of the chemistry instruction there since. The chemistry department has since grown to such an extent that it now has a faculty of five members.

CHEMISTRY AT SOUTHWESTERN UNIVERSITY

Chemistry teaching began in this institution in the fall of 1891 with Professor R. S. Heyer in charge. He was joined by Dr. John Reedy * about 1912, and in 1915 both of them were transferred to the Southern Methodist University at Dallas. Then Dr. J. C. Godby,* Ph. D., Chicago, became professor of chemistry.

CHEMISTRY AT THE SAM HOUSTON STATE TEACHERS COLLEGE

The first teacher of chemistry at this institution was Robert B. Hally. He was succeeded in 1901 by Professor Claude Bohn Farrington, B.S., Vanderbilt. The chemistry faculty was increased in 1925 by the addition of Professor L. E. King, B.S., U. of Texas, and in 1936, by the addition of Professor Willis W. Floyd,* Ph. D., Iowa.

CHEMISTRY AT HARDIN-SIMMONS UNIVERSITY

Simmons College—now Hardin-Simmons University—was organized in 1893 but no serious scientific study was pursued before 1902. Dr. Julius Olsen,* Ph. D., Yale, came as Dean and Head of Mathematics and Sciences at that time. He developed and equipped a department to teach two years of physics and two years of chemistry. Biology was added as a college department in 1914 and David Wesley Arnett, M.A., Wake Forrest, has taught in that department until now. Following the World War No. 1 work was expanded again with professors of physics and of chemistry elected and a major in each science made possible. Otto O. Watts,* Ph. D., Stanford, was elected professor of chemistry and Dr. Olsen taught physics. In 1922 another chemistry expansion brought Hyram R. Arrant, M.A., Vanderbilt, into the department.

CHEMISTRY AT THE NORTH TEXAS STATE TEACHERS COLLEGE

According to the writer's personal recollection, the early teaching of chemistry in this institution was in the hands of Professors W. N. Masters, L. D., Borden, and T. A. Willard, and it could not have been in better hands. Concerning Professor Masters, it may be said that his enthusiasm and vigor was contageous: he succeeded in teaching chemistry in spite of an overload of teaching duties and a scarcity of equipment.

The fruit of the work of these pioneers is seen in the splendid staff of chemistry teachers which this college now has. They are: J. S. Carrico,! J. J. Spurlock,* L. P. Floyd,' R. B. Escue, and Price Truitt. The high degree of scholarship, and the research contributions already made by these men indicate that the college has the right atmosphere for sound teaching and progress.

CHEMISTRY AT THE COLLEGE OF MINES AND METALLURGY

The College of Mines and Metallurgy opened in September 1914 with F. H. Seamon as professor of chemistry. W. W. Lake was added to the staff in 1927 and W. H. Ball in 1929. In 1940, Professor Seamon retired and was succeeded by W. W. Lake as chairman of the department. In 1940 J. L. Abernethy was added and was succeeded by Robert G. Mers in 1941. J. A. Hancock was also added to the staff in 1941. Dr. Mers resigned in 1945. The present staff includes:

* W. W. Lake, Ph. D., Chicago, Professor and Chairman Dept.
W. H. Ball, M.S., Iowa State, Assistant Professor.
J. A. Hancock, M.S., Gonzaga Univ., Assistant Professor.
W. H. Norman, M.S., Texas A. & M., Assistant Professor.
J. W. Scruggs, B.S., Texas A. & M., Instructor.
Barbara Mellen, B.S., Texas College of Mines, Instructor.
Sylvia Galatzan, B.S., Texas College of Mines, Instructor.

CHEMISTRY AT THE RICE INSTITUTE

The Rice Institute was formally opened the fall of 1912 but its first catalogue gives the course announcements for 1916-1917. In this appears the name of Harry B. Weiser, Ph. D., Cornell, as instructor in chemistry. Since 1920, he has been professor of chemistry. Professor Weiser devoted his life to the study of colloids, and is an outstanding leader in this subject. He is the dominating figure in chemistry at Rice, and his example has led the work there admirably.

In 1921, A. J. Hartsook * joined the chemistry staff at Rice as instructor in industrial chemistry, and in 1928 he became assistant professor in charge of the Department of Chemical Engineering.

During these years there have been many brilliant men as instructors in chemistry at this Institute. Rice stands for high attainments in scholarship and research, and this ambition impresses itself indelibly upon its student body.

CHEMISTRY AT THE SOUTHERN METHODIST UNIVERSITY

When this institution opened its doors in 1915, Professor John Reedy *, Ph. D., Yale, was in charge of the instruction. He was succeeded in 1918 by Professor Edward O. Heuse,* Ph. D., Illinois, who is still active in teaching there. The research work of the department has resulted in a number of publications. The patience and perseverence with which Professor Heuse and his over-worked staff are continuing their work cannot but elicit the admiration of all who know him and them.

In 1920, Dr. May Whitsett,* Ph. D., Columbia, joined the staff as associate professor. She is a talented research worker on vitamins. In 1941 she married Dr. B. J. Hopkins, Professor of Chemistry at the University of Illinois, Urbana.

CHEMISTS OF THE SOUTHWESTERN LABORATORIES

These laboratories were organized and primarily directed by F. B. Porter, B.S. and Ch. E., University of Kansas; N. C. Hamner, M.A., University of Virginia, and R. H. Fash, B.S., Armour Institute. These laboratories were established in 1912 and they are now operating in Dallas, Fort Worth, San Antonio, Houston and Corpus Christi. While their routine work concerns itself primarily with the analyzing of minerals and commercial products, yet they do experimental development work to produce new products, or to improve production methods. They have established a splendid record for ability and integrity.

The Houston laboratory was established in 1902 by P. S. Tilson, a graduate of A. & M. College of Texas. His was really the earliest commercial chemical laboratory in Texas. After his death in 1925, the laboratory was acquired by the Southwestern Laboratories.

THE GALVESTON LABORATORY

The Galveston Laboratory was established by Mr. Felix Paquin in 1909. Mr. Paquin was unique in holding to the principle that he must do, personnaly, all the analytical work done in his laboratory. He employed only helpers, and actually did all essential parts of the chemical work himself. A Frenchman with the vivacity and spirit characteristic of the French, he made a visit to his laboratory something which the writer will never forget.

CHEMISTS IN THE STATE PURE FOOD AND DRUG LABORATORY

This laboratory was opened in Denton, in 1907, with J. S. Abbott as director, and ——Hoffman and E. H. Golaz as chemists. In 1911, it was moved to Austin with W. W. Battle as director. Since 1928, it has been a part of the State Health Department with Mr. Golaz as director.

Mr. Golaz was an able and painstaking food analyst, and it is due to his vigilance and integrity that food adulterations in Texas have been suppressed to such an extent as not to be noticeable.

TEXAS' OUTSTANDING CHEMIST IN INDUSTRY: DR. A. M. McAFEE OF THE GULF REFINING CO.

Dr. A. M. McAfee, a Texan who received his undergraduate training at the University of Texas, and his Ph. D. at Columbia, has been active as chief chemist for the Gulf Refining Company in Texas since 1913. It was he who showed the value of aluminum chloride as a catalyst for changing the composition of petroleum hydrocarbons. But when he started, aluminum chloride cost $1.50 a pound, and he realized that it could not be used technically unless it was produced more cheaply. He then elaborated a method of making aluminum chloride which reduced its cost to 5 cents a pound. This achievement is so great that it may be considered as making up for the scarcity of other advances in chemical manufacturing methods in Texas during the period before 1920.

APPENDIX

Biographical Data from AMERICAN MEN OF SCIENCE
for All Names Marked with an Asterisk.

Bailey, Prof. James Robinson, University of Texas, Austin, Texas. Chemistry. Houston, Texas, Dec. 11, 68. A.B., Texas, 91; Ph. D., Munich, 97; Leipzig, 00-01. Asst. Chem. Texas, 91, tutor, 91-94, instr, 96-00, adj. prof, 01, prof. org. chem, 11. Assoc. ed, "Jour. Am. Chem. Soc." A.A.; Chem. Soc.; Petrol. Inst. (director research project No. 20); Texas Acad. Semicarbazid acids; hydrazin acids; hydrazo-acids; hydantoins; mustard oils and hydrazo compounds; use of cyanic and prussic acids in glacial acetic acids; conjugate systems; petroleum bases; destructive distillation of cotton seed meal.

Blake, Dr. John Charles, 1514 E. 68th St., Chicago, Ill. Chemistry. Ottumwa, Iowa, 80. B.S., Colorado 01; Ph. D., Yale, 03. Research assoc. physical chem, Mass. Inst. Tech, 03-05; asst. physicist, Bur. Standards, 05-06; prof. chem. and chem. eng, Agr. and Mech. Col. of Texas, 08-13; chem, Hahnemann Med. Col, Ill, 13-24, dean, 20-24; research chemist, Inst. Am. Meat Packers, Chicago, 29-32; retired. Colloids; dextrins; determination of nitrates.

Carrico, Dr. James Leon, 1711 W. Hickory St., Denton, Texas. Chemistry. Sanger, Texas, Nov. 22, 06. A.B., N. Texas State Teachers Col, 27, B.S., 29; fellow, Texas, 29-31, A.M., 31; Henry Lawes fellow, Calif. Inst. Tech., 32-35, Ph. D., 35. Assoc. prof. chem, N. Texas State Teachers Col., 31-32; prof. physics and chem., Lamar Col., 35-36; pyrolysis research, Texas Co., 36-Texas Acad. Photohalogenation of compounds having a double bond between carbon atoms; pyrolysis of pure hydrocarbons; determination of isoparaffin content of hydrocarbon mixtures.

Everhart, Dr. Edgar, 150 N. Jackson St., Atlanta, Ga. Chemistry. Stokes Co, N. C., April 8, 54. A.B., Racine, 73, A.M., 75; Columbia, 74-75; Fresenius' Lab, Wiesbaden, 76; Ph. D., Freiburg, 78. Asst. chem, Stevens, 78-84; prof. Texas, 84-94; Cox, 94-97; chemist, Ga. Geol. Surv, 04. Chem. Gesell. Organic and physiological chemistry.

Felsing, Prof. William August, 3007 Washington Square, Austin, Texas. Physical and inorganic chemistry. Denton, Texas, May 19, 91. A.B., Texas, 13, A.M., 15; Savage fellow, Mass. Inst. Tech, 17-18, Ph. D., 18. Tutor chem, Texas, 13-16, Asst. Prof, 19, assoc. prof, 19-25, prof, 25—Capt. C.W.S. Chem. Soc.; Texas Sci. Club; Texas Acad. Equation of state; free energy and electromotive work; thermochemistry; low temperature work; selenids; non-aqueous solutions; refrigerating fluids.

Fraps, Dr. George Stronach, College Station, Texas. Chemistry. Raleigh, N. C., Sept. 9, 76. B.S., N. C. State Col. 96; fellow, Hopkins, 98-99, Ph. D., 99. Asst. chem, N. C. State Col, 95-96, asst. prof, 99-03, ast chemist, Exp. Sta, 99-03; Agr. and Mech. Col. of Texas, 03-04, assoc. chemist, 04-05, acting chemist, 05-06, chemist, 06— assoc. prof. chem, col, 04-05, acting prof, 05-06, assoc. prof, 06-12; state chemist, Texas, 06—A.A.,; Chem. Soc; Agr. Chem. (pres, 13); Soc. Agron; Soil Sci. Soc; Soc. Animal Nutrition; Assn. Feed Control Officials (pres, 29); Int. Soc. Soil Sci. Digestion experiments; soils; nitrification; phosphoric acid; methods of agricultural analysis; productive values of feed; vitamins; minerals in feeds.

Godbey, Prof. John Campbell, Southwestern University, Georgetown, Texas. Chemistry. Monroe Co., Mo. July 4, 82. A.B., Cent. Col. (Mo.), 04, A.M., 05; Missouri, 05; Vanderbilt, 08-10; Leipzig, 11-12. Teacher, pub. sch Mo. 05-08; Cent. Col. (Mo.), 10-13; Southern (Ala.), 13-17; prof. chem. and biol. and head dept. chem. Southwestern (Texas), 17—AA.; Chem. Soc. (chairman, cent. Texas sect, 28); fel. Texas Acad. (pres, 35). General chemistry; water gas and its residue; history of mercury; camphor from cedar leaves; slide rule for correcting gas volume.

Gooch, Prof. Wilby T., 808 Speight Ave., Waco, Texas. Chemistry. Waco, Texas, Dec. 22, 85. B.S., Baylor, 06, M.S., 08; Ph. D., Chicago 18. Prof. chem, Baylor, 08—chemist, City Water Works, Waco, 18— A.A.; Chem Soc (past chairman, Texas sect); Water Works Asn; Texas Water Works Asn (pres, 24); fel. Texas Acad. The effect of light on the velocity of saponification of ethyl acetate; the velocity coefficient of saponification of methyl acetate; halogen reactivity; ethylene chlorbromide and chloriodide.

Hedges, Dr. Charles Cleveland, Agricultural and Mechanical College of Texas, College Station, Texas. Chemistry, Chemical Engineering. alton, Ky. Sept. 22, 84. B.S., Kentucky, 06; A.B., Cornell, 08; Ph. D., 12 Asst. instr. chem. Cornell, 06-08, instr. 08-12; assoc. prof, Agr. and Mechanical Col. Texas, 12-13, head dept chem and chem. eng, 13—, v. dean sch. eng, 26— Chem. Soc. Agricultural and inorganic chemistry; elementary qualitative analysis; insecticides; efficiency of engineering teachers.

Harper, Dean Henry Winston, 2216 Rio Grande St., Austin, Texas. Chemistry. Boonville, Mo., Sept. 20, 59. Mount City Col. Boonville, 72-74; Ph. D., Phila. Col. Pharmacy, 81; M. D., Virginia, 92, 94; Europe, 97; LL.D., Baylor, 14; Mfg. chemist and perfumer, Ft. Worth, Texas, 81-84; chemist and metallurgist, Colo. and Refugio Mining and Smelting Co., 84-85; Compania La Imogena, 86; chemist and pathologist to Drs. Beall and Adams, Ft. Worth, Texas, 87-90; adj. prof. chem, Texas, 94-97, assoc. prof, in charge sch. chem. and director chem. lab. 97-03, prof. chem, 03—, dean grad. sch., 13— Chemist, Miner. Surv. Texas, 01-06. 5th, 7th and 8th Int. Congs. Applied Chem. Naval consulting board, south, div, S.A.T.C., 17-18. A.A; Chem Soc; Electrochem, Soc; Soc. Chem. Indust; Electrochem. Soc; fel. Inst. Chem; Am Med Asn; South Med. Asn; fel. Texas Acad (pres, 00, v. pres, 10); fel. London Chem. Soc; Soc. Chem. Indust. London. Pharmacology; geology; pathology; chemistry of fatigue; chemistry of asphalt; amethystine blue; water analysis; analysis of several artesian waters; municipal water supply of El Paso, Texas; the waxes in the candalilla plant; bituminous coal distillation: hydrolysis of sawdust; bromids and iodids from deep wells of Texas; chemistry of the pollen of the mountain cedar.

Hartsook, Prof. Arthur J., Rice Institute, Houston, Texas. Chemistry. Greenwood, Nebr. Nov. 17, 91. A.B., Nebr. Wesleyan 11; B.S., Mass. Inst. Tech. 20, Monsanto fellow, 20-21, M.S. 21. Instr and sch supt Nebr 12-18; instr indust. chem, Rice Inst. 21-28, asst. prof. chem. eng. and in charge Dept, 28—. Chem. Soc. (Pres. southeast Texas sect, 26—, sec'y, 30—). Industrial chemistry; chemical engineering; decomposition and products of natural gas.

Henze, Prof. Henry Rudolf, 309 Moore Blvd., Austin, Texas. Chemistry, New Haven, Conn., Jan. 11, 96. Ph. B, Yale, 18, Nat. Aniline and Chem. Co. fellow, 20-21, Ph. D., 21. Adj. prof. chem. col pharmacy, Texas, 21-22, assoc prof, 22-24, prof, 24-27, head dept, 21-27, prof. pharmaceut. chem, 27—, chairman dept. chem, 29— Junior chemist, U. S. Bur. Mines and C.W.S., 18, major, C.W. Res. A.A.; Chem. Soc. (pres. cent. Texas sect, 31, 32, 37, councilor, 32, 33); Pharmaceut. Asn; fel Inst. Chem; Texas Phamaceut Asn; fel. Texas Acad. Pharmaceutical chemistry; ingidoid dyes, hydantoins; halogenated ethers; calculation of isomeric and stereomeric aliphatic compounds; heterocyclic nitrogen compounds.

Heuse, Prof. Edward Otto, 3421 University Blvd., Dallas, Texas. Chemistry. Madison, Ind., March, 79. B.S., Hanover Col, 00, hon. A.M., 06; M.S., Illinois, 07, fellow, 12-14, Ph. D, 14. Asst. Chem, Illinois, 03-07; prof, Upper Oowa, 08-12; instr, Illinois, 14-15; prof, Monmouth Col, 15-18; prof. and head dept, South. Methodist, 18— Summer, Lewis Inst. (Ill.), 07. A.A.; Chem. Soc; fel. Inst. Chem; Texas Acad. Physical and Inorganic Chemistry.

Hogan, Prof. Francis Woodall, Texas Christian University, Ft. Worth, Texas. Chemistry. Nashville, Tenn., Oct. 6, 87. B.S., Vanderbilt, 11, M.S., 12, 12-14; Chicago 24, 26. Instr. Chem. Vanderbilt, 14-15; asst. prof., Ward-Belmont Sch, 15-20; prof. Texas Christian, 20—, chairman div. nat. sciences and math. A.A.; Chem. Soc. Closure for a carbon cylinder with a method for spontaneous creation of pressure within the cylinder; recovery of waste carbon dioxide and waste heat from cement kilns; hydrogen sulfide from natural gas.

Lake, Prof. William Wattes, College of Mines and Metallurgy, El Paso, Texas. Chemistry. Ridgewood, Ohio, June 8, 91. B.S., Ohio State, 13, M.S., 21; Ph. D. Chicago, 41. Chemist, National Carbon Co., Cleveland, Ohio, 13; chief chemist, William Edwards Col, 14; instr., high school, Ohio, 14-17; Texas, 19-21, head science dept, El Paso Jr. Col., 21-27, asst. prof. chem. Col. Mines and Metal, Texas, 27-35, assoc. prof. 35-40; prof. and chairman dept., 40—. 2nd lieut., Inf., 18-19. Chem. Soc. The synthesis of DL-threose.

Landolt, Dr. George Lifred, Austin College, Sherman, Texas. Chemistry. Somerville, Texas, May 19, 02. A.B., Austin Col, 23, A.M., 26; Ph. D., Pittsburgh, 30. Instr. chem. Austin Col, 24-26; Asst, Pittsburgh, 26-28; head dept, S. Park Junior Col, 28-31; Austin Col, 31—, Pres, Southwest, Sci. Supply So., Beaumont, Texas. Summer, lecturer, Austin Col, 31. Preparation, manufacture and activity of organic flotation reagents.

Lochte, Prof. Harry Louis, University of Texas, Austin, Texas. Chemistry. Fredericksburg, Texas, Oct. 18, 92. A.B., Texas, 18; fellow, Illinois, 21-22, Ph. D., 22. Teacher, high chs, 11-16; asst, and tutor, Texas and Illinois, 16-22; instr. chem, Texas, 22-23, adj. prof, 23-26, assoc. prof, 26-36, prof, 36— Chem. Soc. Organic and analytical chemistry; naphthenic acids; bomb methods of analysis for carbon; corrosion of iron.

Wallet, Dr. John William, University of Virginia, Charlottesville, Va. Chemistry, Dublin, Ireland. Oct. 10, 32. Ph. D., Gottingen, 52; A.B., Dublin, 53; M.D., Louisiana, 68; LL.D., William and Mary and Mississippi, 72; Princeton, 9; Hopkins, 02; Pennsylvania, 06. Prof. chem, Alabama, 56-60; Med. Col. of Ala, 60-61; first lieut. and A.D.C., staff of Gen. Rodes, C.S.A., 61-62; capt, maj, lieut. col. of artillery and supt. C. S Ordnance Laboratories, 62-65; prof chem, med dept, Louisiana, 65-68; Virginia, 68-83; prof. chem. and chairman of the faculty, Texas, 83-84; prof. chem, Jefferson Med. Col, Phila, 84-85; Virginia, 85-08, emer. prof. 08— Judge, bur. awards, Centennial Expos, 76; lecturer, Hopkins, 77, 78; mem. U. S. Assay Commission, 86, 88, 96; ed, "Zeitschrift Anorg. Chem." 92— F.A.A.; Chem. Soc. (pres, 82); assoc. fel. Am. Acad; Philos. Soc; cor. mem. N. Y. Acad; hon. men. Md. Med. and Chirug. Faculty; hon. mem. Soc. Mex de Hist. Nat; Soc. Cient. Ant. Alz; fel. Royal Soc; Fel. London Chem. Soc. (v. pres, 88-90). General and applied chemistry and chemical mineralology; atomic masses of lithium, aluminum and gold; density of solid mercury; molecular weight of hydrofluoric acid; methods for determination of organic matter in potable water; new meteorites; occurrence of silver in volcanic ash from South American volcanoes; structure and absorption spectrum of gold leaf. d. 1912.

McAfee, Dr. Almer McDuffie, P. O. Box 316, Port Arthur, Texas. Chemistry. Corsicana, Texas, Sept. 24, 86. A.B., Texas, 08; fellow, Columbia, 10-11, Ph. D, 11. Tutor chem, Texas, 08-10; chemist, Texas Co, 11-13; chief research chemist, Gulf Ref. Co, 13-23, supt. aluminum chlorid dept, 23— A.A.; Chem. Soc; Soc. Chem. Indust; Chem. Eng. Petroleum oils; manufacture of gasoline; aluminum chlorid.

Olsen, Dean Julius, Simmons University, Abilene, Texas. Physics. Chicago, Ill., May 5, 73. B.S, Bethany (Kans.), 98, hon. Sc. D, 22; Ph. D, Yale, 02. Prof. physics, Simmons (Texas), 02-03, dean dept. arts and sciences, 09-27. A.A.; Physical Soc. Physical Chem.

Reid, Prof. E. Emmett, Johns Hopkins University, Baltimore, Md. Chemistry, Fincastle, Va., June 27, 72. A.M., Richmond, 92, LL.D, 17; fellow, Hopkins, 97-98, Ph. D, 98. Prof. chem, Col. of Charleston, 98-01; Baylor, 01-08; Carnegie asst, Hopkins, 08-09, Johnston scholar, 09-11; research chemist, Colgate and Co, 11-14; assoc. prof. chem, Hopkins, 14-16, prof. org. chem, 16-37, emer. prof. chem, 37— Consultant, E. I. du Pont de Nemours and Co, 19—; Hercules Powder Co, 26—; Thiokol Corp, 34—; Socony-Vacuum Oil, 37—; research adviser, Richmond, South Carolina, Emory, Furman, Birmingham-Southern Col. and Howard Col. Summer, visiting prof, Chicago, 30. Consultant gas warfare, U. S. Bur. Mines and War Dept, 18-19; consultant, C.W.S., Edgewood Arsenal, 20—; Chem. Soc. (chairman, div. org. chem, 20, director, 34-37); Inst. Chem. Organic Chemistry; hydrolysis and alcoholysis of acid amids; the formation of nitriles; organic sulfur compounds; relative solubilities; organic catalysis; identification of caids, alcohols and phenols; anthraquinone thio-ethers; influence of sulfur on the color of dyes; ethylation of benzene; derivatives of "mustard gas"; high speed stirring; isomers and series.

Reedy, Prof. John Henry, University of Illinois, Urbana, Ill. Chemistry. Plano, Texas, May 1, 79. A.B, A.M, Southwestern (Texas), 00; M.S., Chicago, 14; Ph. D, Yale, 15. Prof.

chem, Southwestern (Texas), 05-13; South. Methodist, 15-18; asst. prof. and assoc. prof, Illinois, 18—; Chem. Soc.; Electrochem. Soc. Inorganic and analytical chemistry.

Schoch, Prof. Eugene Paul, 2212 Nueces St., Austin, Texas. Chemistry. Berlin, Germany, Oct. 16, 71. C.E, Texas, 94, A.M, 96; fellow, Chicago, 99-00, Ph. D, 02. Instr. chem, Texas, 97-06, adj. prof, 06-11, prof, 11—, director bur. indust. chem, 14—; Texas Acad. (pres, 08). A.A. Chem. Soc.; Inst. Chem. Engrs. Physical and industrial chemistry; electromotive force of nickel; systematic electroanalysis; water treating; economic products from polyhalite; improving lignite as a fuel; effect of electric discharge upon hydrocarbons.

Thornton, Marmaduke Knox, Jr., Agricultural and Mechanical College of Texas, College Station, Texas. Chemical engineering. Helena, Ark., Feb. 8, 92. B.S., Miss. Agr. and Mech. Col, 09; A.M, Columbia, 14. Chemist, Tenn. Coal, Iron and Ry. Co, Ala., 09-11; instr. Agr. and Mech. Col. Texas, 11-15; junior chemist, ordnance dept, Picatinny Arsenal, J. J., 15-18; shift supervisor, Hercules Powder Co, 18-19; prof, indust. chem. Agr. and Mech. Col. Texas, 19-35, leather specialist, exten. service, 36—; Chem. Soc. Explosives; fuels for internal combustion engines; lubricating oils; lubrication of engines; cottonseed oil milling and refining; paints; timber preservation; cottonseed products; leather and leather products.

Watts, Prof. Otto Olive, 1925 Simmons Ave., Abilene, Texas. Chemistry. Brentwood, Ark., March 21, 93. A. B. Simmons Col. (Texas) 13, Rice Inst, 16; A.M, Colorado, 23; Ph. D, Stanford, 32. Asst. and instr, Colorado, 22-24; prof. chem. and head dept, Simmons, 20-22, 24-34, Hardin-Simmons, 34—. Teaching fellow, Stanford, 30-32. Summers, acting asst. prof, Stanford, 30-32; visiting prof, Col. Mines and Metal, Texas, 36, 37. Instr, A.E.F. Univ. Beaune, 18. A.A.; Chem. Soc; Texas Acad. (v. pres. in charge, physical sciences, 37); Texas Archeol. and Paleont. Soc. (sec'y, 29, 32-36). Thermometric titration method; electrical conductivity; viscosity and plasticity in the mesomorphic state; lyotropic properties of starch sols.

Whitman, Prof. James Laurence, Texas Christian University, Fort Worth, Texas. Chemistry. Pendleton, Oregon, March 9, 92. A.B, Oregon, 14, M.S, 15; Ph. D., Iowa, 24. Teacher, high sch, 15-19; head dept, chem, Spokane, 19-21; instr. anal. chem, Oregon, 21-22, physical chem, Iowa, 24-28; prof. chem. and head dept, Texas Christian, 28—; A.A.; Chem. Soc. (sec'y) Iowa sect, 27, pres, 28, cent, Texas sect, 32; Texas Acad. Conductivity in mixed solvents; electrometric determination of reducing sugars; colloids; physical properties of binary liquid systems.

Weiser, Dean Harry Boyer, Rice Institute, Houston, Texas. Chemistry. Canal Winchester, Ohio, Sept. 5, 87. A.B, Ohio State, 11, A.M, 12; Ph. D, Cornell, 14. Instr. chem, Tennessee, 14-15; Rice Inst, 15-18, ast. prof, 18-19, prof, 19—, dean, 33—; Chairman cmt. on chem. of colloids, Nat. Research Council. Assoc. ed, "Jour. Physical Chem." Capt, C.W.S. A.A.; Chem. Soc. (sec'y, div. inorg. and physical chem, 24, v. sec'y, 25, chairman, 26, chairman, colloid div.); fel. Inst. Chem; Eng. Educ; Faraday Soc. Absorption; chemical production of light; the hydrous oxides; physical character of precipitates; theory of dyeing and mordanting; setting of hydraulic plasters; stability of colloidal solution; permeability of membranes; colloidal theory of gallstone formation; constitution of gels and sols from x-ray and electron diffraction studies; mechanism of the electrolyte coagulation of sols.

ANTI-FREEZE COMPOUNDS—DESIRABLE CHARACTERISTICS AND PRESENT STATUS

MARSHALL BROWN
Supervising Laboratory Engineer
Texas Highway Department

SYNOPSIS

Present shortage of satisfactory anti-freeze compounds and reappearance of inferior and injurious materials threaten to intensify motor vehicle shortage by damage to radiators and motors.

Very simple tests for detecting inferior products are described and desirable characteristics of anti-freeze compounds are listed and briefly discussed.

The present anti-freeze situation appears to offer an excellent opportunity to see if the old platitudes concerning burned children avoiding the fire and experience being the best teacher apply to the American public.

In 1942 the damage to motor vehicles by deleterious anti-freeze compounds was so extensive that the temporary effect on the war effort was serious. Measures taken to remedy the situation were, to say the least, lenient and, in some ways, inconsistent and ineffective. After much damage was done, the War Production Board prohibited the manufacture, but not the sale, of saline and petroleum base anti-freezes but later reversed itself to the extent of lifting the ban on some petroleum base compounds while the assignment of ceiling prices to the deleterious materials by O.P.A. was apparently interpreted by many as official certification of quality. Promotional schemes took full advantage of previous advertising that had fixed the mind of the public on the value of a "permanent" anti-freeze and "guaranteed permanent" (which they were) labels were commonly used. In some cases trade names of established reputations were closely imitated. Quite a few commercial laboratories and some consultants loaned the advertising a cloak of "scientific" approval by issuing letters and reports, mainly confined to listing the ingredients found, freezing points of various water-compound blends, and general statements such as that the "compound in question compared favorably with other solutions used in corrosion tests" without saying what the other solutions were. Many men with considerable technical training and experience apparently lost sight of such simple facts as, (a) despite recurring statements to the contrary, no inhibitor has been successful in protecting the combination of metals to be found in the cooling system of a car against the corrosive action of magnesium or calcium chloride, (b) all inhibitors are gradually depleted by use, and (c) short time corrosion tests based on visual appearance or loss of weight are not reliable in evaluating anti-freeze, since most of the damage done is due to "hidden" corrosion.

All of the conditions described have been given considerable publicity by newspapers, and such agencies as the American Automobile Association, Better Business Bureaus, and Consumers Research, but once more the substitute anti-freeze compounds are on the market and it will be interesting to watch reaction of the consumer.

The requirements of an ideal anti-freeze compound have been listed and discussed by several investigators.[1] These requirements are essentially as follows:

1. Ability to lower freezing point of water sufficiently to provide adequate protection at lowest winter temperatures.

2. Lack of any tendency to corrode any metal parts of the radiator or motor or to soften or deteriorate rubber connections.

3. Adequate supply at reasonable price.

4. High resistance to decomposition at operating temperatures.

5. Low viscosity at all operating temperatures, high specific heat and high heat conductivity of water solutions.

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1 Anti-Freeze Compounds, Keyes, I, and E. Chem. 0'27. Properties Vs. Performance of Present-Day Anti-Freeze Solutions, Green, Lamprey, and Sommer, Journal of Chemical Education.

6. Should have no tendency to foam nor to produce unpleasant odors or produce undue fire hazard and vapors should be non-toxic.

7. It should not attack automobile finishes and should maintain its anti-freeze property over a long period of time.

8. It should not appreciably alter the boiling point of water.

The "tried and true" anti-freeze compounds are methanol, ethanol, and ethylene glycol,[2] the last named being known as the "permanent" type because little of it is lost by boiling away in service.

Ethylene glycol is the basic ingredient of many dependable products sold under various trade names being originally utilized in Prestone. Compounds based on ethylene glycol have the fact plainly stated on the label along with full directions in regard to methods of use to obtain best results. Considerable basic research [2] has been done to improve anti-freezes by imparting such properties as anti-foaming, anti-air entraining, lack of tendency to "creep" or cause leaks, etc. The shortage of ethylene glycol, which originated early during the war and still exists, gave rise to the vigorous promotion of saline solutions and petroleum products as "permanent" anti-freeze compounds.

The methanol and ethanol products provide adequate protection against freezing and meet the anti-corrosive requirements but have certain minor disadvantages chief of which is loss by evaporation, surging, etc., which place these products in the "nonpermanent" class. They are not recommended for use in high altitudes. They will damage car finishes and some objection, particularly to methanol, has been raised concerning the toxic nature of the fumes. However, the last named objection hardly seems justified in view of the long service record without any deleterious effects, at least in this area, being reported.

As in the case of ethylene glycol, the methanol and ethanol products are sold under various trade names with the basic ingredient being plainly listed on the label along with specific instructions and precautions regarding use. Considerable quantities are also sold in bulk. Although not available in unlimited quantities, the methanol and ethanol shortage has never been as acute as the shortage of ethylene glycol.

SALINE SOLUTIONS

Solutions of salts, chiefly calcium chloride and sometimes magnesium chloride, have constituted the bulk of the substitute anti-freezes. They satisfy two of the major requirements for an anti-freeze namely, adequate freezing point lowering and adequate supply at reasonable cost. In fact their price and availability made them a "natural" as substitutes. They are indeed "permanent" which was another "natural" to associate them with the long established advertising regarding quality and price of ethylene glycol base products. However, the corrosive effects of these materials overbalance by far any of their durable properties.

Although these materials are seldom labeled in regard to content, they can easily be detected by very simple tests, namely, gallon weight determination and simple evaporation.

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[2] For those interested in detailed information on these materials, "Properties Vs. Performance of Present Day Anti-Freeze Solutions," by Green, Lamprey, and Sommer, Journal of Chemical Education is recommended reading.

The saline solutions weigh from 10.1 to 11.5 lbs. per gallon while the ethylene glycol products weigh about 9.4 lbs. per gallon and the methanol and ethanol products weigh from 6.75 to 7 lbs. per gallon.

The evaporation test on saline solutions is generally a little startling to "unsuspecting victims." These materials are generally sold in practically saturated solutions.

Petroleum Products

Practically all of the petroleum product anti-freezes are essentially "deodorized" kercsense. Although their unit weight is about the same as that of the methanol and ethanol products they are easily identified by their oily, sticky, feel, and characteristic odor, in spite of the deodorizing treatment, and boiling range, which is very high in comparison to the alcohols, and by the fact that directions call for their being used undiluted.

High boiling point, and deleterious effect on rubber connections are the chief disadvantages of petroleum product anti-freezes; and they are not recommended, although they have no corrosive action comparable to the saline solutions. At least one petroleum base product, labeled as such, is being advertised on a national scale in popular magazines.

Other products such as honey, sugar, etc., have been tried as antifreeze substitutes but price and availability apparently kept them off the market during recent years. They are unsatisfactory and easily detected by their well known characteristics.

RANGE OF CALOPOGON PULCHELLUS IN TEXAS

WILLIAM D. LEWIS AND JAMES L. LIVERMAN
A. & M. College of Texas
(Collegiate Section)

Calopogon pulchellus, commonly known as "Grass Pink," is a **terrestrial** orchid with showy flowers varying in color from pure white to deep crimson. The inflorescence is a terminal raceme borne on a scape 1-13.5 dm tall with a single fully developed leaf sheathing the stem near the base (Fig. 1).

This past spring the writers discovered **Calopogon pulchellus** (1947) four miles south-southwest of Wellborn in Brazos County, Texas, thus advancing the reported range of this species several miles to the southwest. The exceptionally damp, warm conditions of late spring must have been very favorable for **Calopogon** for about the time the authors made their find, Mr. H. B. Parks, Curator of S. M. Tracy Herbarium of the A. & M. College of Texas, discovered this same species in another area 2½ miles southwest of Wellborn and about four miles from the above location. The plants continued to bloom periodically for 10 to 15 days after their first discovery. The former known range in Texas as reported by Correll (1944) included Lamar, Leon, Anderson, Hardin, Harris, Houston, Jasper, Jefferson, Polk, Smith and San Augustine Counties (Fig. 2). Not included in Correll's publication are two more range extensions—one found by Barkley (1943) near New Baden in

Robertson County and one reported by Whitehouse (1940) from Nacogdoches County.

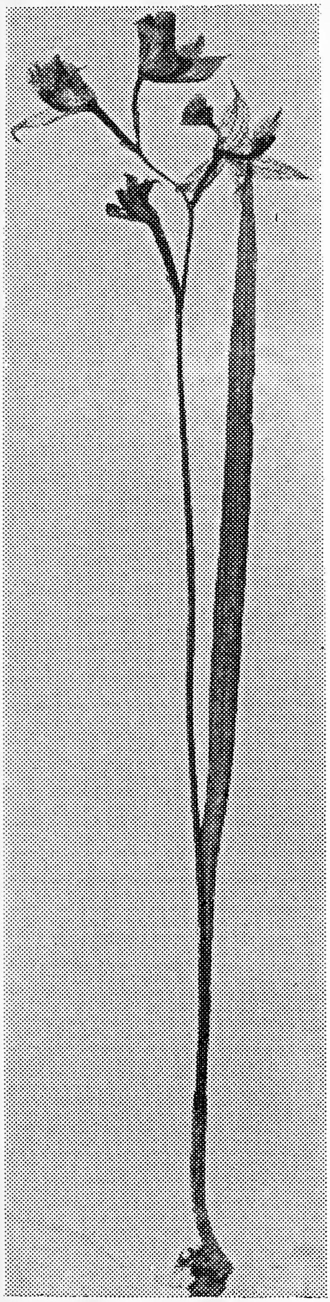

FIG. 1
Photo of **Colopogon pulchellus**

(Collections determined as this species by C. V. Morton of the U. S. National Herbarium have been made in both the Chisos and Davis Mountains of western Texas and published in check lists by Dr. Omer E. Sperry. The western Texas plants have since been worked by Dr. Correll for his monograph on the Orchidaceae and published in The Flora of Texas. The name **Hexalectris warnockii** has been given the above collections by Ames and Correll).

In addition to being found in the post oak and low pinelands of East Texas, **Calopogon** occurs freely in sphagnum bogs, depressions in prairies and savannahs, in meadows and on sandy pine and oak ridges from Newfoundland and Eastern Canada south through the eastern states to Florida. From Florida it ranges along the Gulf Coast to Texas, north through Oklahoma, Missouri and Iowa, and west through the lake states to Minnesota. It has also been reported from the Bahama Islands.

Carlson, (1943) working with this species, has made a study of the developmental anatomy and morphology extending over a period of two years of cultivation on artificial media. A brief resume of her findings will be of interest. The following, unless otherwise stated, has been extracted from her report.

The plant arises from a minute seed which averages .68 mm in length and .20 mm in width. It consists of a transparent, loose fitting seed coat and an ellipsoidal embryo, which consists of a mass of undifferentiated parechymatous cells with none of the usually well defined parts of an embryo. All food is stored in the form of oil which is converted to starch and sugars when germination begins.

The seed germinates, splitting the seed coat, and the basal end enlarges greatly while at the same time the upper part divides producing a typical promeristem

(Carlson, 1943). Epidermal cells elongate to form absorbing organs resembling root hairs and a cone-shaped bud develops from the promeristem. Shortly after formation of the bud, the tubular primordia of the first and second leaves arise and enclose it, and they in turn are followed by formation of the third and fourth leaves each pushing through an opening in the end of the preceding leaf and becoming slightly longer than its predecessor.

The first root of the seedling may arise from a group of parenchymatous cells in the outer cortex of the upper part of the corm; or, as is often the case, this root fails to develop at all. In this instance, a primordium may arise in the bud between the first and second leaves and emerge by digestion of the stem epidermis and some of the leaf cells. In some cases, no root at all develops and absorption is then accomplished entirely by means of the epidermis and absorbing hairs.

By mid-season of the first year, the young plant consists of the protocorm with absorbing hairs, the shoot with four concentric leaves and usually with an adventitious root.

During the latter part of this first season the meristematic tip of the stem stops growing, and a second corm begins to form by elongation and enlargement of the parenchymatous cells of the two upper internodes of the stem. The first internode may elongate to form a stalk of variable length between the protocorm and the new corm. It may be of interest to state here that the authors found such a structure existing on one of the plants they collected.

This second corm soon becomes much larger due to the transfer of reserve food from the protocorm and the manufacture of food by the leaves and by the corm itself since its outer layers contain chlorplasts. As the corm continues to develop, a new bud develops under the epidermis and soon lays down primordia of four new leaves. These soon elongate above the surface and remain until winter approaches when they dry up, leaving only their sheaths which cover the dormant corm with its buds and leaf primordia for the next season.

The second year is a repetition of the last part of the first growing season except that the plant becomes larger and the fourth leaf fails to elongate, making the third leaf the predominant one. A third corm is formed which is larger than either of the previous two but no inflorescence is produced. The advent of winter sees the leaves wither again, leaving only the third corm with its dormant bud.

Carlson studied older plants collected from the field and concluded that this same process is repeated year after year with an increase in the size of the corm and the number of adventitious roots until both internal and external conditions favor flowering. At this time a single leaf and the scape, which is to bear 6 to 12 beautiful flowers varying from white to deep crimson, appears above the ground. Just how many years are required for the complete cycle has not yet been ascertained. Thus it becomes more apparent why this species may be found only on very rare occasions.

Be this as it may, the fact remains that "Grass Pink" has been discovered farther west than has been reported before, and with a group of

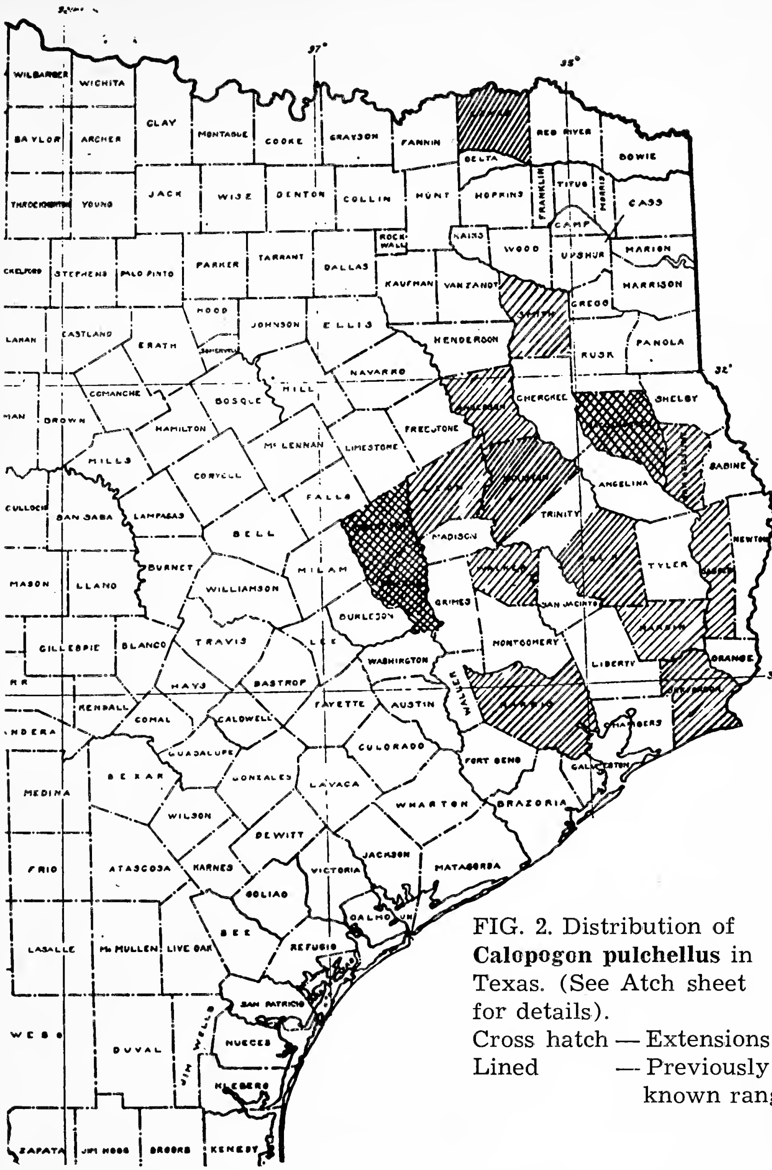

FIG. 2. Distribution of **Calopogon pulchellus** in Texas. (See Atch sheet for details).
Cross hatch — Extensions
Lined — Previously known range

Anderson Co., E. D. Schulz s.n.; Brazos Co., J. L. Liverman and Wm. D. Lewis 87; Hardin Co., G. C. Nealley s.n., O. Sanders and R. Sanders s.n.; Harris Co., F. J. Lindheimer 88, F. W. Thurow s.n.; Houston Co., E. J. Palmer 12070, B. C. Tharp 768; Jasper Co., H. B. Parks and V. L. Cory 22186; Jefferson Co., Mrs. J. L. Hooks s.n., Mrs. S. R. Smith; Lamar Co., E. McMullen s.n.; Leon Co., C. L. Lundell and A. A. Lundell 10338; Nacogdoches Co., Whitehouse 11173; Polk Co., B. C. Tharp s.n.; San Augustine Co., Mrs. W. D. Lynch s.n.; Smith Co., J. Reverchon 2239, 2795; Walker Co., S. R. Warner 113, M. S. Young s.n.

wide awake collectors in the field, it is expected that **Calopogon pulchellus** will be discovered to range in nearly all of the counties of East Texas.

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HUMAN CONSERVATION: HUMAN GENETICS, EUGENIC AND DYSGENIC PRACTICES

C. P. OLIVER, Councillor,
University of Texas, Austin

Human genetics is one of the most misunderstood sciences. Everyone believes that he knows what is best for himself. He has his own theories about heredity in the human and about the relative importance of heredity and environment in affecting human characteristics. There may be no scientific support for his theories, but it is difficult to shake him from his beliefs.

Erroneous ideas about human heredity are often expressed. One such belief which is relatively common is that nothing can be done to prevent a trait with a hereditary basis from occurring. A member of a family having a diseased condition which is manifested only in middle or late adult life may believe throughout his life that he will develop this trait. A geneticist may be able to study the family and show that the person most probably will not develop that defect. Many individuals believe that genetics is synonymous with eugenics. The two sciences are related only in that eugenics attempts to apply the knowledge gained in the study of genetics.

Because of the many misunderstandings about heredity, the human race has blundered along with little attempt to control the appearance of its defective conditions. Little thought has been given to the children of the future. Society should begin to think more about these children.

A program developed to prevent the production of defective children will be more likely to succeed if accurate data about heredity and environmental factors affecting our characteristics are collected and analyzed. New methods for the study of human genetics are now available, and newer methods must be discovered. Some persons can be told that they cannot transmit a trait. Yet too many normal individuals are carriers of a defective trait which they can transmit to their children, and with our present knowledge we are unable to warn them of that fact. These are the ones who suffer most from the production of children with anomalies. Methods of helping these carriers recognize that they have the potentiality should be developed.

As a means to correct erroneous beliefs about heredity and also to place human genetics on a firmer basis, a definite program should be established. The study will require the cooperation of all persons interested in the problems. It should be organized on a permanent basis because the study must begin with living individuals who have the traits to be studied and should continue for a time in order that the data about the relatives can be checked and completed. In such a study cases which occur sporadically are as important as those which occur in several members of a given family. The program will take a considerable time, more than many will want to give, but the end results will be valuable to all of us. The program will progress slowly at first and then will grow rapidly.

PURPOSE

The program to be suggested will have two main purposes. One will be to benefit the living individual. We should help him understand his own genetic problems and make it possible for him to get the most benefit from his genetic constitution by taking advantage of all new knowledge. The other purpose for the study will be to help the children of the future. They have a right to expect the best biological opportunity possible. In modern society these children face a severe competition and should not have to start life under handicaps which make it impossible for them to live a useful life.

Program: The program which is suggested will establish a Center to stimulate and coordinate the study of human genetics. The Center will function:

1. In collecting and keeping files on good and bad hereditary traits, in analyzing the data collected, and in studying the effects of the traits on the population.
2. As an office where people may consult with trained personnel about personal genetic problems confronting them.
3. As a source of information to be used in educating people as to the true interpretations of heredity and the application of the knowledge of heredity to mankind.
4. In making a quantitative study of the population of Texas.

Collection of Records: In collecting and filing information about hereditary traits, the Center will use the data already available in the literature. These records will be evaluated with respect to each characteristic, and the information will be kept on file for use by persons who have a genuine interest in the material.

Original information about families having hereditary or probably hereditary traits also will be collected. Original studies will be made about traits occurring in individual families who from one source or another come to the attention of the Center. However, some specific research projects covering certain conditions, such as mongolism, will be organized. The study of twins will be made.

All data are to be filed so that new information about the family can be added as it becomes available. All such data will be checked for accuracy and completeness. The records must be kept in strictest confidence and used only for research purposes. As a matter of expediency, the traits first to be considered will be those which are undesirable. However, the program will be broadened to include normal traits, non-pathologic variations, special abilities, longevity, and metabolic defects.

An important part of the study will be the collection of data to be used in linkage analyses. Some families who seek information about a hereditary anomaly in the family will be asked to give other personal facts about their non-abnormal traits. Tests will be made to discover whether any of these have a tendency to be inherited with the anomaly. The benefit of such a study is obvious. Once a linkage relationship has been established, congenital traits may be used in predicting with greater accuracy that an anomaly occurring late in life, such as ataxia or chorea, is likely later to occur in a given individual of the family.

Data collected by the Center will be analyzed to determine the mechanism of inheritance of a specific trait in each family. Comparisons will be made with the recognized method of inheritance in other families having a similar condition. Variability in manifestation and the cause of such varied expression of the trait are important. This variability may often result from an environmental agent. The study must therefore attempt to gather data about the environmental conditions under which the trait developed and an analysis of the probable effects must be made.

CONSULTATION SERVICE

Persons will be informed that they may bring their genetic problems or fears to the Center for interpretations. All consultations will be kept in strict confidence.

This consultation service is one means of practicing eugenics. It is often possible after studying a complete genetic history of the family for one to advise with considerable accuracy the probability that an individual will develop a trait present in his relatives. He may also be advised that he will transmit a gene for the trait to his children or that certain marriages will increase the probability that he will produce such a child. On the other hand, one may be able to state definitely that a given member of a family will not have the familial trait and can not pass it on to his child.

EDUCATIONAL PROGRAM

The Center will attempt to bring to the attention of the public the present knowledge we have about human genetics. It will stress the possible use that can be made of such knowledge. For example, one can often use a family history to determine how severe some defects will be in a member of the family. By calling a person's attention to the probable inheritance of a condition, one may help the individual recognize an early manifestation of a non-congenital trait so that he can be treated before it is too late, sometimes helping to preserve life. Differences in accomplishment by members of a family can sometimes be understood as a hereditary variant. Certainly this will be helpful to a child who cannot fill a family occupation of his father or older brother.

The educational program will be carried on by the consultation service and by other means. The Center will publish and distribute non-technical pamphlets which explain heredity and discuss the problems which may arise in families having certain genetic conditions.

A series of talks and discussions will be established and made available to small and large groups who have an interest in genetics. These discussions will be given by various persons who understand human genetics and should be modified when necessary to fit the needs of special groups of listeners. A means of working with young people and of interesting them in their own hereditary histories should be developed. Probably a good beginning will be to establish cooperation with science clubs and similar groups.

A wider application of heredity will be possible if an attempt is made to interest so-called minority groups in the program. This may serve as a means to correct some of the present misunderstandings.

POPULATION ANALYSIS

A quantitative analysis of the population is essential. This will involve studies to determine which traits have severe effects upon our population. Not only must we determine the traits, but we must discover the actual causes of the defects. In retarded children, for example, several casual factors may be active. In some, mental incapacity may be due to metabolic defects, glandular defects or other hereditary factors. Other children may have certain physical defects which are responsible for the lack of proper mental attainment, such as hereditary optic atrophy, other unrecognized vision defects, or difficulty in hearing which may or may not be hereditary. In still other children, the seemingly slow mental development may have an economic cause, such as frequent changes in schools or low finances and a resulting poor health. We need to know how many retarded children fall into each category.

The population analysis should also include the study of relative rates cf reproduction of the various hereditary types and their possible effects upon the future population. Methcds of control which have been practiced by other groups and other parts of our own society should be evaluated. Some cf the laws made to control defectives have been based upon misunderstandings of the laws of heredity. One state, for example, has a law prohibiting marriage between cousins, but by law it permits the superintendent of certain state institutions to act as a justice to perform the marriage ceremony for persons in these institutions. In our study, it will be necessary to determine what can be done to help the children, but bad laws are worse than no laws.

CONCLUSION

Any program in the study of human conservation will succeed only if we have the cooperation of other people who are interested in the project. This can best be gained by establishing a Center which will collect enough data about human genetics to show what is taking place and then analyze the data to show what the future will probably be. Once the data are available pecple will awaken to the need to apply the knowledge properly and intelligently in attacking the problems of society.

SOCIAL PROBLEMS OF MIGRATORY LABOR IN TEXAS

DANIEL RUSSELL
Department of Agricultural Economics
A. & M. College of Texas

A few days ago I was talking to a group of my Texas A. & M. students through the women's penitentiary at Huntsville. The young men were especially attracted by the young convict girl that met us at the front door. She was an attractive, willowy, erect young brunette about 20 years old. She was a young girl that might have passed easily at any of the college dances. Naturally, we did not ask any questions of her, but later the boys interrogated the warden and his wife. We were told that although the girl was a beautiful girl, she could neither read nor write, and that she had been a member of a farm migratory labor family driving over Texas, Oklahoma, Arkansas, Louisiana, and other states following the seasonal demand for this kind of labor. She had no opportunity of an education, no opportunity of any normal life other girls enjoy as she, I am sure, would have liked to have.

A few years ago I heard Mrs. Stevens, the superintendent of the Texas Girls Reformatory at Gainesville, say before a public meeting that 75 percent of the girls at Gainesville reformatory at that time were from these migratory families, driving up and down the highways of this and other states. That life is especially difficult for young women. They want to have dates, go to parties and dances like other girls. They might get dates but seldom, if ever, with the best boys in the community and with boys with the best intentions.

A roving life is not a natural, healthy social life, especially where people do not, as our nomads used to do, carry around with them the rest of their community, their community controls and their community institutions. Man obeys many of the natural laws of the rest of life round about us. Man suffers sometimes more by making this life unnatural than do animals or plants. It is not best to change the habitat of an animal frequently each month. We know the handicap of digging plants up and transplanting them from one area to another area several times each year. People have roots in communities and in social structures and in social institutions in the local community. To tear out these roots and let the people shift and drift around is an unhealthy social situation. So unhealthy, in fact, that I do not think this conference or any of the other conferences we hold can solve or nulify these problems.

Still, migratory labor is a natural result of our changing agricultural, social and economic order. We have migratory labor to meet an economic demand of a new order of life. We cannot change this demand. Therefore, we cannot change this situation. We need to discuss our problems, however, to understand, and to improve our rather unwholesome and unhealthy condition as much as possible. This is a sick spot in our society that we cannot cure, but we ought to try to relieve it. Some men do full days' work when the doctor has told them they will never be real well again. We must have something like that in the problem we discussed today.

Let us list briefly some of our major social problems caused by migratory labor.

(1) We break the solidity of the community in which migrant workers drift and destroy the common consensus that one time existed in these communities. (2) We hurt the community institutions, especially the school, the church, and home, in these communities where we do not have a permanent population. (3) Controls of the local community most often fail to function in the lives of the migrant worker because he is not a part of the local community. (4) We tend to develop misunderstanding, prejudice, and friction between two groups which, if they are not different, they think they are different—which amounts to the same thing in the long run. (5) We fail to give a satisfying home life to the migratory worker and the members of his family, the kind of life we feel necessary for the development of the full, round, human personality. (6) We deny additional opportunities to the children of the migrant farm workers' family. (7) We deny proper religious and moral development to the worker and his family. (8) We create health hazards, first to the migratory worker and second, to the persons in the community where the worker goes. Conditions under which the migratory worker lives are not, as a rule, healthy and sanitary; moving around in a truck over the country is not a healthy situation. Persons visiting many places and areas have greater opportunity to contact and spread infectious diseases. (9) Housing has been, and is, a major problem of migratory workers despite what Mr. Hohn and his fine co-workers in the Extension Service have done to improve the housing facilities for them. This study reminds me of the story of the family of 13 migratory workers living in a one room shack, sleeping on cotton in the middle of the floor and cooking and eating in the great out-of-doors. This may be a marginal case but such conditions occur all too often. (10) We have known for a long time that mobility makes for social disorganization, crime, and delinquency. I think much credit is due to the migratory workers that the crime and delinquency rate is not higher than it is, but it is too high just the same. (11) A person who drifts around a lot does not have permanent moorings, may be an easy prey to the isms and off-brand political and religious doctrines contacted, and such a life does not tend to develop the strong, sturdy citizenship, qualities we expect an American citizen to develop, whether he be farmer, laborer, professional man or, if you please, a migratory worker.

Mr| Chairman, I am afraid I have just opened up some of the problems that should be discussed, with no attempt to solve them.

CORROSION IN HOT WATER SYSTEMS

A. H. ULLRICH, Supt.
Water and Sewage Treatment
Austin, Texas

A complete study of corrosion in hot water systems presupposes a knowledge of the general characteristics of metals and the effect of water on them. It is, therefore, helpful to remember that few metals except the noble ones, such as gold, are commonly found in the metallic state in nature. From this we may reason that the less noble metals, such as iron, are not stable in their metallic state when exposed to the forces of nature. These metals are normally found in some stage of oxidation as an oxide, carbonate, sulphide or similar stable combination which we refer to as an ore. In general, metals which can only be produced by the reduction of ores will revert to more stable forms similar to the original ores from which they came unless they are protected from the forces of nature.

In order to determine how to protect metals from natural corrosion it is essential that we learn what forces of nature are destructive. A number of theories on corrosion have been proposed but in recent years we have pretty generally come to accept the electro-chemical theory as best explaining what actually happens. This theory is based on the fact that all metals have a tendency to dissolve in water, even though the extent of such solution may be very small. The extent of solution is actually governed by the degree of the tendency to displace hydrogen in water, which may be measured in electrical terms as voltage and is a characteristic of the metal. Thus metallic potassium exerts a very high tendency or voltage, iron exerts a medium tendency or voltage and platinum exerts a very low tendency or voltage. The tendency of other metals to go into solution; that is, their solution pressure is intermediate between that of potassium and platinum.

The solution pressure of potassium is so great that when metallic potassium is brought into contact with water, hydrogen is displaced with great violence. The potassium is, therefore, very quickly dissolved or "corroded" to the more stable potassium hydroxide. The solution pressure of metallic iron is less than that of potassium and when metallic iron is brought into contact with water only a limited amount of hydrogen is displaced, except in quite acid solutions as we will note later. The hydrogen displaced adheres to the surface of the iron and both insulates it and exerts a counter solution pressure which has a tendency to prevent additional iron from dissolving. In order for corrosion to continue further, there must be a process of removing the hydrogen. In water containing dissolved oxygen this hydrogen film may be removed by the reaction with oxygen, thus continuing the corrosion process as long as a continuous supply of dissolved oxygen reaches the iron surface or the replaced hydrogen.

If the products of corrosion; iron hydroxide, iron oxide, etc., in the case of iron, were impervious to and excluded any further dissolved oxygen from reaching the iron then corrosion would cease after an adequate film of rust had formed. Since iron rust is not impervious, the corrosion of iron continues. On the other hand, while both zinc and aluminum have higher solution tendencies than iron, they have a tendency to protect themselves by forming very nearly impervious hydroxides and oxides as well as by exerting a high tendency to hold the hydrogen and preventing it from being oxidized. For this reason both zinc and aluminum are very resistant to corrosion in what we term neutral water. Of course, if the water is either acid or very alkaline the zinc or aluminum hydroxides become soluble and the metal corrodes at an increased rate.

While different metals have varying tendencies to go into solution this tendency of each metal also varies with the type of water brought into contact with it. As stated above, in order for the metal to go into solution it must displace hydrogen or its equivalent and any hydrogen displaced must come from that part of the water which is ionized. Therefore, if we have a high hydrogen ion concentration (low pH or acid water) the hydrogen is more easily displaced and we may except rapid corrosion. Conversely, if we have a low hydrogen ion concentration (high pH or alkaline water) the hydrogen is less easily displaced and we may expect less rapid corrosion. From this we might reason that all we have to do to stop corrosion of iron is to increase the pH or render the water sufficiently alkaline. This we cannot do, however, because the resulting water would not be potable. Since we must stay below a truly protective pH we are limited further by the possible destructive action of excessive pH values on some of our present accepted protective coatings and linings.

As previously mentioned, dissolved oxygen in water plays a major role in the corrosion of metals in that it reacts with and removes the protective hydrogen film formed during the first stage of corrosion. It may then be reasoned that the higher the dissolved oxygen concentration, the more rapid the reaction with hydrogen and the more rapid the corrosion. It is also reasonable to suppose that there may be minimum dissolved oxygen concentrations below which corrosion is not unduly aggressive. In studies made on Dallas, Texas, water, Billings has reported that when the dissolved oxygen concentration dropped to or below 7.9 parts per million it was not noticeably aggressive. In studies made on the very soft, low mineral content Fort Smith, Arkansas, water, the author found that when the dissolved oxygen concentration dropped to or below 6.5 parts per million it was not noticeably aggressive. Exact concentrations where definite corrosion rates are encountered are, of course, difficult to determine and, no doubt, change with different types of water.

While reaction with dissolved oxygen is accepted to be the most important way in which the hydrogen film formed in the first step of corrosion of iron is removed this hydrogen may also be removed by a sweeping action such as is obtained in rapidly moving water and by the application of excessive heat. It is also possible that we have overlooked the importance of other oxidizing agents such as high chlorine residuals on the hydrogen film.

Thus far we have considered corrosion only as applied in the case where one metal is in contact with water. Where two or more metals having different solution tendencies are in contact with each other and with water we have the more destructive case commonly called galvanic action. Thus if zinc and iron are in contact with water the zinc is destroyed in preference to the iron. However, if we have copper and iron in contact with each other and both in contact with water, the iron is destroyed in preference to the copper. Similarly, if we have iron in contact with a solution of copper such as copper sulphate, the iron will go into solution, replacing the copper which is plated out. Perhaps a better example of this action is the plating out of metallic silver on a copper penny when the latter is submersed in a solution of silver nitrate.

Galvanic corrosion may also be caused by having low potential insoluble metallic salts in contact with high potential metals and water. In a recent corrosion study made for the Arkansas Tuberculosis Sanatorium the author found that excessive pitting in copper hot water pipe was caused by galvanic action between small deposits (specks) of manganese dioxide and the copper. This case involved all of the hot water piping in one one million dollar building unit and in several smaller units, all constructed in 1939. The corrosion was so severe as to cause numerous failures through pitting by late 1946.

Impure metals in contact with water may also be a source of galvanic corrosion. Thus if two metals of different potentials are in a mixture rather than in solution with each other; that is, if they are not in true alloy, the high potential metal is likely to corrode at an excessive rate.

Still other causes of corrosion include the type obtained when an external electric current is permitted to pass through a system where a metal or metals are in contact with water or a solution. This is known as electrolysis and involves the same general principles as electroplating. Obviously the degree of destruction encountered in this type of corrosion depends on the volume of current passed and this in turn depends on the source of the current and on the resistance which the system exerts. It is generally believed that alternating current does not cause electrolytic corrosion and that direct current is necessary. However, the grounding of any electric appliance to water piping has come in for a great deal of discussion. It is believed that appliances which have condensers or converters may pass enough direct current on to the ground to cause troublesome red water even if the corrosion is not pronounced enough to cause rapid pipe failure.

In the discussion to this point we have considered the corrosion of all metals. Since in water supply our chief interest is in iron, we shall limit further discussion as much as possible to the corrosion of this metal. We may then list the following facts concerning the corrosion of iron:

1. At atmospheric temperatures, iron will not corrode in the absence of water or moisture. Therefore, if we can provide a coating or lining which will prevent water from reaching the iron surface we can definitely protect iron. Linings which have been used with some success include zinc (galvanizing), bitumastic enamels, cement, paints, and glass. Coatings or linings formed by chemical reaction within the water which have been used include calcium carbonate, silicates and phosphates. More will be said about coatings and linings later.

2. All waters have a tendency to corrode iron. This tendency is greatest in acid or low pH waters and lowest in alkaline or high pH waters. In the treatment of potable waters the pH cannot ordinarily be increased sufficiently to give adequate protection by this method alone.

3. Free carbon dioxide and other acids increase corrosion both by increasing the corroding tendency of iron and by dissolving protective coatings.

4. Very high pH or alkaline waters reduce the corroding tendency but if the pH is excessive it may be destructive to protective coatings such as galvanizing and thereby actually increase corrosion in such systems.

5. Dissolved oxygen or other oxidizing agents must be present in

any except acid waters to support continuing corrosion. Also, the rate of corrosion depends on the oxygen concentration and on the rate at which it is replenished. In acid waters the hydrogen film previously mentioned may be removed by direct action.

6. Dissimilar metals in contact with each other and with water will cause corrosion by galvanic action. Thus brass or copper in contact with iron will cause the iron to corrode. Even two different types of iron in contact with each other may cause galvanic action.

7. Direct electric current passing from iron into water and out again will cause the iron to corrode.

8. High temperatures will increase the rate of corrosion.

9. High water velocities tend to increase corrosion by sweeping away the hydrogen film and by increasing the supply of dissolved oxygen reaching the surface of the iron.

10. The solution or corroding tendency of iron may be neutralized by application of a counter acting voltage. This is accomplished in practice by the use of cathodic protection. Cathodic protection may involve either the use of a counter direct current or an expendable metallic anode.

11. It is thought by many that high sulphate and possibly high chloride concentrations cause higher corrosion rates.

12. There has been a general opinion that soft waters are more corrosive than hard waters. It is possible that high calcium and high carbonate concentrations tend to produce complex iron salts with corrosion products to form better protective coatings than do the less complex iron oxides.

This brings us to the question of corrosion in hot water systems. This question has become of intense interest in some areas in recent years because of unprecedented failures of domestic hot water heaters of the galvanized tank type. Usually a sharp increase in such failures has been noted after a change from a hard or relatively hard to a soft water supply has been made or after the complete softening of a water supply has been undertaken. In our haste to explain this phenomenon we might be led to assume that a soft water is intrinsically more corrosive than a hard water. Where a complete change in water supply has been made it is possible that the new supply does not have more corrosive tendencies than the old supply but when the only change has been intensive softening, then it is apparent that this should not be the chief and only factor.

During the years that the author was associated with the Fort Smith, Arkansas, Water Department, he had an excellent opportunity to observe the results of a change in water supplies. The original supply was normally relatively soft, but for frequent short periods it did carry considerable calcium bicarbonate hardness. With this supply there was sufficient carbonate scale formation in storage tank type hot water heaters to give adequate protection against corrosion. In 1936 Fort Smith changed to a very soft lake water supply and within two years after the change there were complaints of new galvanized tank hot water heater failures. As one of the leading local wholesale plumbing firms exhibited considerable interest, we collaborated on an investigation of one of their better heaters of reputable make. We selected a galvanized tank type heater which had been in service just long enough to cause some complaint from red water and which had been placed in service some time after the change to the very soft water supply. This tank was removed from service, taken to the firm's shop, and cut into upper and lower halves. Inspection of the inside surfaces revealed numerous spots where the galvanizing had disappeared completely and where instead there was rusting and pitting. The galvanizing which remained seemed to be considerably thinner than the original coat was assumed to have been. There was no scale or other deposit except the rust on the exposed spots. Further inspection revealed that the heater contained a tin down pipe in contact with the galvanized iron of the top of the heater and a brass thermostat in contact with the side of the heater shell. This heater had iron, zinc, tin and brass all in electrical contact with each other and when in operation, with water. To check our suspicion that, through galvanic action, the tin and brass was removing the zinc galvanizing and then destroying the iron, we suspended the tin down pipe in one half of the tank filled with water and measured the current which flowed between it and the tank shell. This was some six milli amperes. In like manner, we measured the current flowing between the brass thermostat and the heater shell and obtained similar results. With this destruction active continuously twenty-four hours each day, there was small wonder that the heater was giving red water complaints.

From studies made on the two Fort Smith supplies, the Arkansas Tuberculosis Sanatorium supply and from studies as reported in the literature by others, the author has drawn the following conclusions regarding corrosion in hot water systems:

1. That the ordinary galvanized tank hot water heater with brass, tin or copper down pipe and brass thermostat will destroy itself through galvanic action if used with soft, non-scale forming water.

2. That for a galvanized tank hot water heater of this type to give reasonably satisfactory service it must be used with a water having sufficient carbonate or temporary hardness to form a protective scale, with a water which is purposely treated to form a protective coating on all interior parts of the heater or with a water low in dissolved oxygen.

3. That treating a low calcium and low carbonate water to calcium carbonate stability with lime is not sufficient to form a protective coating in hot water heaters and piping. If calcium carbonate stability can only be reached by treating to a high pH then there is not sufficient calcium carbonate present to form an adequate coating.

4. That the excess lime treatment in lime softening, if not carefully controlled, may be detrimental to galvanized hot water tanks. It is likely that if the water is treated to a very high pH and the high pH is maintained in the finished water, the calcium carbonate solubility is depressed below the point where it can form an adequate protective coating.

5. That waters which have sufficient calcium bicarbonate hardness form adequate protective coatings through their deposition of scale.

6. That with very soft waters, excessive pH values are harmful. With Fort Smith water a pH of 8.8 was found to soften galvanizing. Higher pH values were found to remove it and expose the iron.

7. That excessive temperatures will cause rapid corrosion.

8. That deaeration or oxygen removal will aid in reducing corrosion both in hot and cold water systems. This has been practiced in boiler plants and other industrial installations. It has not been practical to deaerate or practice oxygen removal in treating municipal supplies.

9. That silicate treatments when properly supervised may form adequate protective coatings to reduce corrosion.

10. That copper coil instantaneous heaters and copper lined and monel metal tank heaters are successful with soft, non-scale forming waters. Recent reports on glass lined tank heaters have also been encouraging.

11. That low dosages of sodium hexametaphosphate (1.0 ppm. or less) will not protect hot water systems when used with a low calcium and low carbonate water. That dosages of 5.0 ppm. or more, may give protection under these conditions.

12. That phosphates such as micromet will give protection when used in the recommended dosages.

13. That the use of dissimilar metals should be discouraged, especially in hot water systems using non-scale forming water.

In conclusion, I would like to emphasibe that each water is an individual problem and its corroding tendency must be given individual study. Because corrosion rates are often very slow, such studies may be rather time consuming. However, to arrive at satisfactory solutions, we must study the characteristics of each water as well as evaluate the degree of protection we wish to accomplish.

PROPOSED GROUNDWATER CONSERVATION MEASURES IN TEXAS

WILLIAM F. HUGHES *

Declines in groundwater levels that have resulted from expanded agricultural, industrial, and municipal water uses in Texas have stimulated some interest and effort in promoting statutory regulation of groundwater use. Texas is not alone in respect to groundwater problems. Groundwater levels have declined, some of them excessively, throughout most of the United States.

With the exception of a few western states, groundwater development in this nation has proceeded without legislative restraint. In some states, however, utilization has been regulated somewhat by application of the American doctrine of reasonable use.

Efforts to rectify the situation in states where statutory controls are not in effect have not been universally successful. The lack of success in several of these efforts is not unusual under the circumstances. Once a state is committed to a policy of unrestricted use, it is exceedingly difficult to bring about the legislative action required to establish adequate conservation measures.

* Agricultural Economist with the Bureau of Agricultural Economics, U. S. Department of Agriculture. The opinions expressed are those of the author unless otherwise cited and are not necessarily those of the agency with which the author is associated.

Lack of Regulatory Features in Present Law

Texas has constitutional and statutory provision relating to the appropriation and use of water flowing in natural watercourses, underflow to these watercourses, and to artesian waters, but these provisions do not apply to percolating waters. Inasmuch as the groundwaters with which we are here concerned come within the classification of percolating waters, existing statutes need no further discussion here.

Groundwater development and use in Texas is not subject to statutory control. The few court decisions bearing on the subject hold that percolating waters are the absolute property of the landowner. For a time Texas courts were inclined to accept the American doctrine of reasonable use,[1] but a Texas Supreme Court decision handed down in 1904 established the English doctrine as the accepted law governing the taking and use of groundwater. The provisions of the English common law doctrine are stated in the following quotation:

> "That the person who owns the surface may dig therein, and apply all that is there found to his own purpose at his free will and pleasure; and that if, in the exercise of such right, he intercepts or drains off the water collected from the underground springs in his neighbor's well, this inconvenience to his neighbor falls within the description of damnum absque injuria, which can not become the ground of an action." (Quoting from the English case of Action v. Blundell (12 M. & W. 324, 354), a decision rendered in 1843.)

At the time the original decision was rendered, 1843, knowledge of the physical conditions governing the occurrence of groundwater, its source, quantity, rate of movement, and destination was conjectural, or at best was very meager. Perhaps the courts could not rule otherwise when the subject in question was an unknown quantity, with neither its source nor mode of occurrence known. This was true to a large extent in 1904, when the Texas Supreme Court accepted the provisions of the 1843 decision as being applicable to the problem under consideration. Considerable progress was made in groundwater hydrology between 1843 and 1904, but unfortunately many of the hydrologic principles that were brought to light were not well enough established to influence the latter court's decision.

Marked advances in groundwater hydrology have been made in recent years. It is now possible to approximate, with a reasonable degree of accuracy, the limits of a particular underground water-bearing formation, its storage capacity, its rate of replenishment, and its potential yield. Lack of knowledge was probably sufficient justification for the early decisions, but no such claims can be substantiated today.

A close study of the provisions of the English doctrine indicates that groundwater development and use in Texas is proceeding under a policy of every man for himself. It is also readily apparent that if carried to its logical conclusion this process can lead to only one end—depletion of the existing water supplies.

Need for Conservation Measures

No vivid imagination is required to foresee the consequences of unregulated use. This is particularly true in the field of irrigation.

1 The provisions of the Doctrine of reasonable use vary between the states in which it is recognized. In general, however, this rule holds that each owner of land overlying a basin has a right to the underground water co-equal and correlative with that of all other owners of land overlying the same basin.

Remnants of irrigation facilities and foundations of houses that were abandoned when the artesian pressure head dropped in the Roswell Artesian Basin, show what can happen to an irrigated area when the water supply is depleted. Other examples of the economic losses sustained when a water supply fails are found in the Winter Garden Area of Texas, the Mimbres Valley of New Mexico, and in some of the inland valleys of California where large sums have been expended in an effort to replenish depleted groundwater supplies.

In the domain of municipal and industrial water uses the bare possibility of a depleted or contaminated supply is loaded with far-reaching economic implications—implications that are of prime concern to tax-conscious city officials and industrially-minded chambers of commerce alike. Cities, unlike individuals or irrigation districts that have scant financial resources, can usually take advantage of surface storage to offset the effects of a depleted water supply. Such a shift, however, usually requires rather heavy capital expenditures. Even in those cases where a municipality can take advantage of minimum storage costs through public water control or conservation constructions, transportation and increased facilities for treatment are still expensive. If a municipality must bear the full expense of storage construction, the cost is often prohibitive. In addition, the quality of the water obtained, even with increased treatment, is often lower than that of groundwater. Moreover, the supply is not always dependable. For those cities that are not in a position to take advantage of surface storage, any curtailment or impairment of their water supply would effectively limit their further expansion and, in extreme circumstances, might conceivably force a reduction in current activities.

Interested individuals began agitating for statutory control of groundwater use as long as 15 years ago, but these efforts were not widely supported. Later efforts, despite increased interest in the subject have fared no better. Diverging opinions and the conflict of interests among various agricultural, municipal and industrial water users have stifled all attempts to establish the required legislation.

Despite the wide range of interests encompassed by the opposition forces, one phrase in the enabling clause of the proposed legislation has served to unite them in a common effort. The enabling clause, declaring the waters of underground streams, channels, artesian basins, reservoirs, or lakes having reasonably ascertainable boundaries to be the **property of the state** and to be subject to appropriation for certain uses, if enacted into law would abrogate the now accepted English doctrine and make groundwater use more or less subject to the existing appropriation stautes. Regulation in any form is, naturally, objectionable to the groups whose activities might be hampered, while some people who might not object to the regulation of groundwater use in general are strongly opposed to the idea of state ownership of water in their own area.

According to Hutchins (1942), "The principle of ownership of percolating waters by the owner of the overlying land, either absolutely or subject to reasonable use, has been so thoroughly grounded in American jurisprudence as to make introduction of the appropriation doctrine a difficult matter . . . In line with this, uses have become vested upon the basis of court decisions recognizing ownership by the landowner, after which any declaration of public ownership and appropriability immediately raises constitutional questions."

Counsel for the proponents of groundwater conservation hold that Section 59a, Art. XVI of the Texas Constitution provides ample constitutional leeway for the enactment of such legislation as may be required for the proper conservation of groundwater resources. The controversial oil and gas proration statutes of Texas were enacted under the provisions of this Section and proponents of statutory regulation of groundwater use consider that it provides a mandate for the enactment of the desired measures. Sections 59a, b, and c, Art. XVI of the State Constitution, which contain the provisions under which the proposed conservation measures would be enacted, are reproduced below.

"Sec. 59a. The conservation and development of all the natural resources of this State, including the control, storing, preservation and distribution of its storm and flood waters, and waters of its rivers and streams, for irrigation, power and all other useful purposes, the reclamation and irrigation of its arid, and other, lands needing irrigation, the reclamation and drainage of its overflowed lands, and other lands needing drainage, the conservation and development of its forests, water and hydroelectric power, the navigation of its inland and coastal waters, and the preservation and conservation of all such natural resources of the State are each and all hereby declred public rights and duties; and the Legislature shall pass all such laws as may be appropriate thereto.

"(b) There may be created within the State of Texas, or the State may be divided into, such number of conservation and reclamation districts as may be determined to be essential to the accomplishment of the purposes of this amendment to the constitution which districts shall be governmental agencies and bodies politic and corporate with powers of government and with the authority to exercise such rights, privileges and functions concerning the subject matter of this amendment as may be conferred by law.

"(c) The Legislature shall authorize all such indebtedness as may be necessary to provide all improvements and maintenance thereof requisite to the achievement of the purposes of this amendment, and all such indebtedness may be evidenced by bonds of such conservation and reclamation districts, to be issued under such regulations as may be prescribed by law and shall also, authorize the levy and collection within such districts of all such taxes, equitably distributed, as may be necessary for the payment of the interest and the creation of a sinking fund for the payment of such bonds; and also for the maintenance of such districts and improvements, and such indebtedness shall be a lien upon the property assessed for the payment thereof; provided the Legislature shall not authorize the issuance of any bonds or provide for any indebtedness against any reclamation district unless such proposition shall first be submitted to the qualified property-tax-paying voters of such district and the proposition adopted. (Sec. 59, Art. 16, adopted election Aug. 21, 1917; proclamation October 2, 1917.)"

Provisions of the Proposed Conservation Measures

Legislation to effect the required changes in the State Water Code was introduced in the Legislature during the regular sessions of 1937, 1939, 1941, and 1947. All these proposals met with such vigorous opposition that none of them received Committee approval. The provisions in these proposed measures are similar, in most respects, and adhere closely to those of the suggested "Uniform Underground Water Law for Western States" which was prepared by a committee of the Association of Western State Engineers in 1935.

In the discussion that follows, the main provisions of the various proposed conservation measures are outlined and some of their more salient features along with certain points of issue are discussed.

1. Each proposal sought to abrogate the now accepted common law doctrine and replace it with the Doctrine of Appropriation. Use

would be regulated by the granting of a permit to appropriate a given quantity of water from a known source for a definite purpose.

2. The provisions in the proposed measures would be applicable to all water uses throughout the State. The manner in which regulatory measures would become effective, however, differ somewhat between the various proposals. In the 1937 and 1939 proposals the regulatory features would become effective only if people in a particular area wanted them, and took the required steps. Under the 1941 and 1947 proposals the regulatory features would have become effective throughout the state with the enactment of the proposed legislation.

The local option approach would provide the means whereby the majority of the people in any particular area could invoke the regulations to conserve their water supply. The actual conservation of groundwater resources, however, stands a much better chance of being achieved under the more flexible method of application embodied in the statewide approach than it does under the local option approach. Regulation on a local option basis would be as effective as statewide regulation only if its application could be as timely. Inertia or delay on the part of local people in instituting the regulatory measures, or the conflict of interests that such a move would bring to light, could easily delay action until irreparable damage is inflicted. On the other hand, if groundwater use is subject to appropriation at all times, the regulatory agency can step in and stop or restrict development in any particular area when it becomes evident that further development will be detrimental to existing appropriated rights.

3. Constitutional authority for the enactment of the proposed conservation measure is presumed to be carried in Section 59a, b, and c, Art. XVI, the previously cited "conservation section," of the State Constitution.

4. Two different legal concepts of the authority for enforcing groundwater use regulations, enacted under the provisions of Sec. 59, Art. XVI, of the State Constitution, are expressed in the proposed measures. In the 1939 and 1941 proposals, regulations would have been enforced through the exercise of the police power without taking title to the underground water resources. Although this approach has some undesirable features from an administrative standpoint, as will be presently noted, it is generally conceded to be constitutional. The authority of the State to impose restrictions on the taking and use of minerals under similar circumstances has been established in court tests of the controversial oil and gas proration statutes. On the other hand, serious doubts have been raised regarding the constitutionality of the approach suggested in the 1937 and 1947 measures. In these measures control would have been exercised through the State taking title to the underground water resources, subject to appropriation and use by individual appropriators.

The state's authority to take title to the underground water resources is not specifically provided for in the appropriation statutes and therein lies the reason for doubting the constitutionality of the 1937 and 1947 approach. In this connection the appropriation statute provides:

"The waters of the ordinary flow and underflow and tides of every flowing river or natural stream, of all lakes, bays or arms of the Gulf of Mexico, and the storm, flood or rain waters of every river or natural stream, canyon, ravine, depression or watershed, within the State of Texas, are hereby declared to be the property of the State, and the right to use thereof may be acquired by appropriation in the manner and for the uses and purposes hereinafter provided, and may be taken or diverted from its natural channel for any of the purposes expressed in this chapter.*** (Vernon's Texas Statutes. 1936, Revised Civil Statutes, Art. 7467.)

It will be noted that in the drafting of the appropriation statutes the framers thereof did not include percolating waters. Inasmuch as the use of percolating waters was subject to the common law doctrine at the time these statutes were drafted, it has been held that this omission constitutes a specific exemption of these waters from the provisions of the appropriation statutes.

From the standpoint of the administrator, the exercise of control through the state taking title to the underground water resources is preferable to the exercise of control through the police power alone. Dedication of the underground water resources to the public provides the legal foundation for their appropriation and use under the regulations and conditions prescribed by the state. Without this dedication, the authority of the state to prescribe and impose regulations would be subject to challenge each time a regulation is imposed, and the ensuing litigation could well defeat the purpose of the conservation movement. Regulation of groundwater use would be a new undertaking and in the absence of previous court decisions bearing on the subject the decisions of the courts probably would be dictated by the particular circumstances surrounding the issue being contested. This process could easily lead to a situation fraught with administrative difficulties and uncertainties for both the administrator and the individual appropriator. With some regulations effective throughout the state and others effective only in particular areas or at particular times, and all subject to possible change with each later court decision, an orderly and efficient administration of the regulatory program would be exceedingly difficult. The individual appropriator, although he may have established his right over that of others in one court, might be forced to resort to litigation each time his right was challenged or impaired.

5. For all practical purposes the State Board of Water Engineers would administer the proposed conservation program. In the 1937 and 1939 proposed measures, with their local option provision, the regulatory program would have been administered through a District Board of Directors. All regulations and control measures imposed by these boards, however, would be subject to the approval of the State Board of Water Engineers. The State Board also would have had the power to require District boundaries to conform to the area it deemed necessary to conserve the groundwater resources of the District and in adjacent areas as well. In the 1941 and 1947 proposals, the State Board of Water Engineers would have been charged with the supervision of the program. They would also have been responsible for the determination of all procedures incident to the administration of the program that were not definitely outlined in the proposed enactment.

Hutchins states (op. cit.) in his discussion, in 1942, regarding a centralized system of public control over water rights:

" . . . while the system as a whole has not been applied as completely in some jurisdictions as in others, and has not met with uniform success in all places, it is undeniable that a long period of time has shown that centralized control over water-right functions is workable. The system is generally conceded in the West to have been of marked public benefit. None of the states which have imposed public control have receded from the principles, excepting in those instances in which specific functions have been rendered inoperative as the result of unfavorable court decisions. The general principle is now well established in most of the western states, for it is widely realized that the foundation of the system is the vital interest of the state in its water resources."

Advantages of placing the administration and supervision of a regulatory program under a centralized agency are many. Uniform regulations can be prescribed and administered in a manner which will avoid much of the dissension that probably would arise around the issue of bias, should the administration of the program be placed in local hands. Moreover, the State Board of Water Engineers has all the data pertaining to existing conditions in a groundwater area and is the only agency that is in a position to determine when the water supply of an area is fully developed. Obviously, this is a determination that cannot be left to the individual or corporation with vested interests. Groundwater investigations are long-drawn-out and expensive undertakings that require the services of technical investigators for at least a short period each year. The central agency that has several simultaneous investigations can employ the services of this personnel and interpret the results of their findings much more efficiently and in a more orderly way than would be possible under an autonomous locally administered program. Furthermore, groundwater conditions in one area may be closely allied with or may be influenced to some extent by those in adjacent areas. The central agency is the only organization that is in a position to give adequate unbiased consideration to these relationships.

6. Beneficial use was the basis and the limit to the right to use of the waters described in the proposed measures.

7. Existing water rights based on application to a beneficial use were recognized and procedures for establishing their priority were provided.

8. The granting of a permit to appropriate water for beneficial uses was mandatory, provided (a) that the applicant had complied with all the prescribed regulations, (b) that unappropriated water was available, and (c) that the proposed development would not be detrimental to existing rights, or not inconsistent with the general public welfare.

9. Between appropriators, the first in time is the first in right, and all permits would be granted subject to the right of municipalities to make further appropriations of water from the same source for domestic and municipal use as their needs arise.

This latter provision is in keeping with existing statutes relating to priority of water use. It is also a point of issue between agricultural, municipal, and industrial water users. There is no argument regarding the propriety of assigning the highest priority of water use to the sustaining of life, but the inclusion of undefined municipal use is another matter. Agricultural water users take the position that water used by an industry is industrial water use irrespective of the fact that it may have been provided by a municipality. Existing statutes do not define the limits to municipal water use and the fact that certain cities are providing industrial concerns with water obtained under a municipal appropriation makes agricultural water users all the more apprehensive of extending this unqualified provision to groundwater use also.

10. Administrative control over groundwater use is contingent on authority to reject applications or to prorate use once a permit is issued. In all the proposed measures, the administrative agency is specifically directed to deny all applications when there is no unappropriated water in the source that the applicant proposes to tap; or if the proposed use would impair existing water rights or is detrimental to the public welfare. Provisions for the proration of use, once a permit is granted, are not specifically provided for in any of the measures. This might be implied, however, in the language of the proposed measures in which the administrative agency is directed to formulate the rules and regulations necessary to carry out the provisions of the proposed legislation.

1. The common law features of existing groundwater law are retained insofar as domestic, stock and home garden use is concerned. The use of water for these purposes is specifically exempted from the appropriation statutes.

12. Any willful diversion and use of groundwater for any of the purposes named, without first complying with all the provisions of the proposed legislation, would be deemed a misdemeanor. Conviction would carry a fine, not to exceed one hundred dollars, or imprisonment in the county jail, for a term not to exceed six months, or both a fine and imprisonment. Each day that the regulations are violated would constitute a separate offense. Possession of the water obtained under these circumstances would be considered **prima facie** proof of the guilt of the party or parties concerned.

13. A definition of what constitutes waste is carried in each of the measures. Provisions for punishing those guilty of causing, suffering or permitting waste are also provided. In the 1937 proposal, use in excess of the normal recharge is considered a waste, but this consideration is not carried in later measures. In them, waste is defined to conform to the ordinary meaning of waste and is declared to be a public nuisance.

14. Similar provisions for the forfeiture of a right through non-use over a definite period of time are carried in all four measures.

15. The provisions of the proposed measure did not, in any case, contemplate the repeal of any Act of the Legislature concerning the conservation, protection, preservation, and distribution of underground water. Each would have constituted an addition to the statutes already in effect. Herein lies another point of issue between agricultural and industrial water users. Enactment of the proposed measures would make groundwater uses subject to the same priorities that govern surface water uses. The statutes relating to the priority of use in the appropriation of water, as will be noted in the quotation which follows, are much better adapted to humid and sub-humid areas than they are to more arid areas where agricultural uses are generally given preference over all but life sustaining water uses. Texas law regarding priority in appropriating water is as follows:

" . . . In the conservation and utilization of water declared the property of the State, the public welfare requires not only the recognition of uses beneficial to the public well being, but requires as a constructive public policy, a declaration of priorities in the allotment and appropriation thereof; and it is hereby declared to be the public policy of the State and essential to the public welfare and for the benefit of the people that in the allotment and appropriation of the waters defined in Article 7467, of revised Civil Statutes of Texas of 1925, preference and priority be given to the following uses in the order named, to-wit:

1. Domestic and municipal uses, including water for sustaining human life and the life of domestic animals.
2. Water to be used in processes designed to convert materials of a lower order of value into form having greater usability and commercial value, and to include water necessary for the development of electric power by means other than hydro-electric.
3. Irrigation.
4. Mining and recovery of minerals.
5. Hydro-electric power.
6. Navigation.
7. Recreation and pleasure."

(Article 7471, Revised Civil Statutes, Page 1370)

In this priority of use it will be noted that, without exception, industrial uses are accorded a higher priority than agricultural uses. This particular priority of use is in direct contrast to the priority that obtains in States where irrigation is practiced to any great extent and it is one of the reasons for a large part of the opposition by agricultural interests. A possible method of curing some of this opposition lies in a revision of existing priority statutes, wherein agricultural uses would be given preference in those areas or sections of the State where such uses are clearly paramount. This approach has proved applicable in other states where the range in climate is similar to that in Texas.

Some of the provisions of the earlier conservation measures were undoubtedly designed to provide only the maximum degree of conservation that the proponents considered possible to enact over the objections of the opposition. In the 1947 proposed measure, however, no retreat from the provisions generally conceded to be necessary to the orderly and effective administration of a groundwater conservation program is apparent. Included in this measure are the controversial provisions that have served to defeat earlier proposals, namely: Statewide application of the appropriation principle to all beneficial water uses, dedication of the underground water resources to the public, and a centralized system of public control over groundwater uses with authority to deny applications.

Despite impressions that may have been imparted regarding the general seriousness of declines in water levels, groundwater resources are being seriously overdrawn in only a few areas of the state (Spence, 1947). In many localities, however, the current rate of use is greater than the recharge, so water is being withdrawn from storage. Evidence of this can be found in news releases regarding difficulties in municipal water supplies and in cooperative reports issued by the U. S. Geological Survey and the State Board of Water Engineers. An accelerated rate of use under these conditions can easily lead to depletion. It seems highly desirable, therefore, that conservation measures be taken before irreparable damage is done.

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METHODS OF COOLING A SAE 1060 STEEL AND THEIR EFFECTS ON THE MICROSTRUCTURE AND PHYSICAL PROPERTIES OF THE STEEL

L. R. BENSON
University of Texas

Carbon steel is essentially an alloy of iron and carbon. Carbon steel also contains manganese, silicon, phosphorus and sulfur, but of these elements, manganese is the only one whose percentage in carbon steel may vary enough to have any appreciable effect on the physical properties of the steel.

In an unhardened steel at room temperatture the carbon in the steel is present as iron carbide, which is also called cementite. The iron is present as alpha iron which has a small amount of carbon, about 0.008% in solution and is called ferrite. In steel at room temperature, the lattice structure is a body centered cubic system, and the ferrite grains appear white under the microscope. Ferrite is a ductile material, relatively soft, Brinell hardness of 50 to 95 and a tensile strength of about 40,000 pounds per square inch. Cementite which has a chemical formula of Fe_3C is very hard and brittle. The amount of cementite in the steel has an effect on the physical properties of the steel. Increasing the amount of cementite in steel will also increase the hardness and the tensile strength of the steel.

The physical properties of a carbon steel are determined not merely by the amount of cementite present, but more especially by the form in which it is present in the steel and the manner in which it is distributed in the steel.

The purpose of this paper is to discuss briefly the processes by which we can control the form in which the cementite will be present and the manner in which it will be distributed in the steel. We shall try to limit our discussion to the processes of control as they apply to a SAE 1060 steel.

At room temperature an unhardened SAE 1060 carbon steel will have a microstructure consisting of free ferrite and pearlite. The pearlite is a laminated structure consisting of alternate laminations of ferrite and cementite. (Fig. 1) The free ferrite is the dark portion, which forms the boundaries for the pearlite, the lighter portion. This photomicrograph made with the electron microscope clearly shows the lamellar structure of the pearlite.

We shall next note the changes that take place in the microstructure of this steel as it is slowly and uniformly heated. When the temperature reaches 1333° F. it will remain at this temperature until all the pearlite has been transformed into austenite. Austenite is defined as a solid solution of cementite in gamma iron. The space lattice structure changes from a body centered cubic to a face centered cubic. The cementite which has an octahedron cell fits into the cubic cell of the gamma iron in such a manner that the carbon atom occupies the center of the cube. As soon as all the pearlite has transformed into austenite the temperature will again continue to rise and the ferrite will transform into

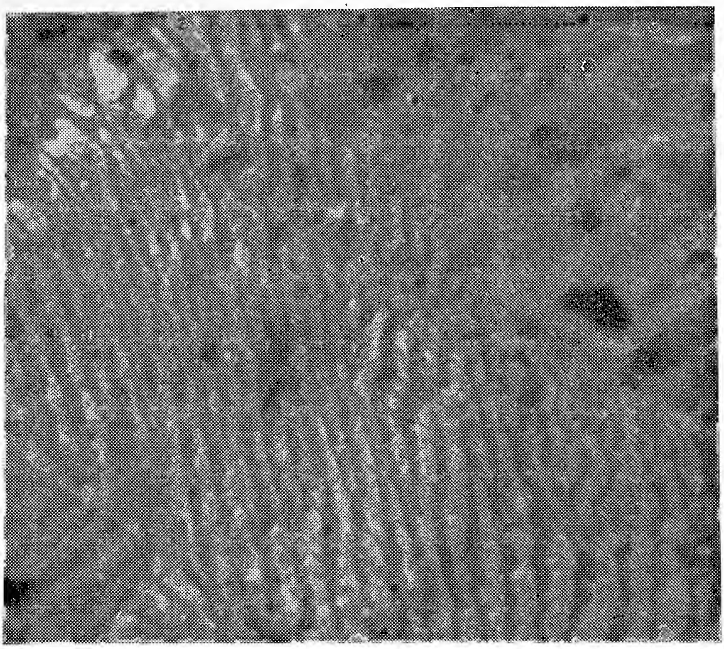


FIG. 1. PEARLITE

austenite. Thus the transformation of the ferrite and pearlite into austenite will be completed at the upper critical temperature of about 1380° F.)

This solid solution, austenite in the form of homogenous grains is the microstructure from which by controlling cooling and by moderate reheating we can create the microstructure that will give us any desired combinations of physical properties within the natural limits of the steel involved.

In order that we may visualize more clearly the various cooling rates that are commercially applied to steel, let us become acquainted with another diagram, called the S-curve diagram or the Transformation-Time-Temperature (TTT) diagram.

This isothermal transformation diagram of a steel may be regarded as a kind of map or working drawing, which enables us to visualize approximately how the steel will respond to any mode of cooling from the austenitic state.

At this point it is essential that we have in mind two very important facts. First.—That if a steel in the austenitic state is held at a constant temperature lower than the minimum at which its austenite is truly stable, it will in time transform. Second.—That once a transformation product is formed from austenite at some given temperature this new structure will not, upon further cooling, change into the transformation product characteristic of the lower temperature.

As stated earlier in this paper we shall limit our discussion to the transformations that result from applying various cooling rates to a SAE 1060 carbon steel.

Let us first consider the transformation which results when cooling the steel in the furnace in which it was heated to the austenitic condition. As the temperature drops from Ac1 (1380° F.) to Ac3 (1333° F) ferrite crystals begin to form in the boundaries of the austenite grains. When the temperature reaches 1333° F it will remain constant until all the remaining austenite transforms into pearlite. This pearlite is a corase lamellar structure of ferrite and cementite. This process of transformation is called nucleation and grain growth, and proceeds by the appearance of centers or nuclei of centers which develop until they abut. The result is some form of ferrite and cementite aggregate. In this process called full annealing the result is grains of coarse pearlite bounded by free ferrite.

A similar microstructure may be had by quenching the austenized steel in a salt bath of a temperature of 1325° F. and holding it at this temperature until the austenite has completely transformed into free ferrite and coarse pearlite. This process of cooling is called isothermal annealing. Although the microstructure produced by these two processes of cooling may appear almost identical under the microscope, the second process generally produces the most uniform structure in a shorter time.

Let us consider next the type of microstructure which is produced when we cool the austenized steel in still air. This process is called normalizing. Since this cooling rate is much faster than cooling in the furnace, less ferrite will have time to form as the temperature drops from 1380° F to 1333° F at which temperature pearlite will form. The rate of nucleation of the pearlite due to transformation at a lower temperature will increase greatly so that the pearlite in this process will have much fine laminations. Since pearlite is nearly three times as strong as ferrite and fine pearlite is stronger than coarse pearlite we will have the normalized steel stronger and harder than a full annealed or isothermal annealed steel.

Annealed SAE 1060 steel — Brinell 187 — Tensile strength 95,000 psi.
Normalized SAE 1060 — Brinell 229 — Tensile strength 107,000 psi.

Another process of cooling is to quench the austenized steel in a salt bath of a temperature of 600° F and hold it at this temperature until all the austenite has transformed. If the quench is rapid enough so that the steel gets by the knee of the curve without any transformation taking place, the result is an unstable supersaturated austenite which transforms into acicular ferrite in which cementite is precipitated. This structure is called bainite and again the transformation is the result of nucleation and grain growth. We may then define bainite as a structure consisting of acicular grains of ferrite in which submicroscopic globular particles of cementite have been precipitated. This type of cooling is called austempering; it produces a steel much harder and stronger than the steel produced by any of the three methods previously mentioned. This increase of hardness and strength is gotten without surrendering too much of that important property, ductility or toughness.

Austempered SAE 1060.—Brinell 388 — Tensile strength 225,000 psi.

In each of these processes of cooling, the transformation of the austenite is the result of nucleation and grain growth, but yet each process produces its own type of microstructure. Professor Albert M. Portevin explains the difference in microstructure in this manner. He says that there are too factors that control the kinetics of transformation. First, the rate of germination or nucleation, that is the number of nuclei which appear in unit time in unit volume of austenite. Second, the rate of growth or the linear rate of propagation of the products of decomposition. To these we would like to add a third factor, namely, that at temperatures above 1100° F cementite controls the nucleation and at temperatures below 1100° F the ferrite controls the nucleation.

Cementite controls the nucleation of pearlite. The coarse pearlite is the result of a slow rate of nucleation and a high rate of grain growth, while fine pearlite is the result of a high rate of nucleation and slow rate of grain growth.

Ferrite controls the nucleation of bainite. The formation of acicular ferrite may be due to stresses created by a lower temperature quench, but the fine globular cementite is due to rapid nucleation.

The transformation of austenite, whether to pearlite or bainite, is dependent upon both time and temperature.

Another process of cooling called hardening of steel is the result of quenching the austenized steel in cold water. An examination of this structure under the microscope (500x or more) will reveal a needle-like acicular structure. This structure etches very lightly so therefore we feel that only one phase is present in the structure. It is the hardest structure that is possible from the transformation of austenite. This structure is called martensite.

Our knowledge of martensite is still meager. However, there is general agreement among metallurgists on the following conclusions. The transformation of austenite to martensite differs from the process of nucleation and grain growth. The transformation is without diffusion of the elements and involves no change in chemical composition. Lattice constant measurements indicate that martensite has the same composition as the parent solid solution, austenite. There is no nucleation and grain growth. Rather small discrete volumes of the parent solid solution suddenly change crystal structure. These martensitic crystals have a typical acicular microstructure in plane section. The lower the temperature of formation the more perfect is the acicular microstructure. The transformation is the result of homogeneous shear and each plate-like volume is a single crystal of martensite. The transformation progresses only while the steel is cooling and will cease if the temperature drop is interrupted. Thus we see that the transformation is independent of time and dependent for its progress only on the temperature drop. Martensite transformations have been shown to be reversible in some metals but it is irreversible in carbon steels. Martensite has been defined as a metastable interstitial solid solution of carbon cementite in teragonal iron (very close to a cubic lattice.)

Whether or not martensite is stable is not of too much concern, as the structure is too brittle to have much commercial value. To alter the microstructure of the hardened steel, it is only necessary to reheat it. This process is called drawing the temper or, more briefly, drawing or tempering.

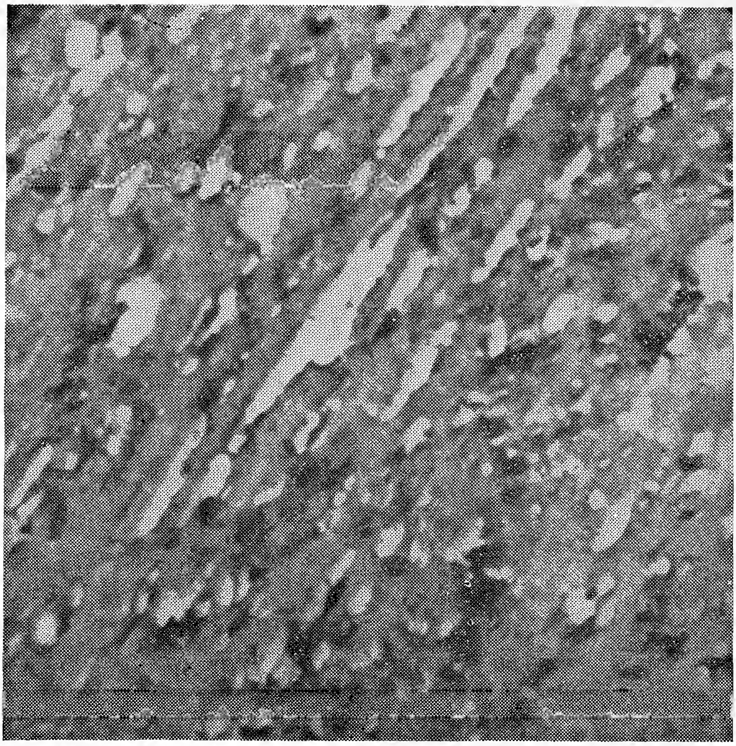


FIG. 2. STEEL TEMPERED TO 750° F

It is possible to get the desired combinations of physical properties in a steel that will make it suitable for the job that is required of it by reheating the hardened steel to some definite temperature. The hardened steel will continue to increase in hardness as the temperature rises to 200° F, but as the temperature continues to rise above 200° F the hardness and the tensile strength will decrease and the toughness will increase.

Although we can definitely determine the physical properties of a tempered steel we are far from certain as to what changes take place in the microstructure of the steel in tempering it. We feel quite certain that as the temperature rises to 200° F the tetragonal space lattice changes to a body centered space lattice. It is possible that the body centered space lattice can not hold as much cementite in solution as the tetragonal space lattice without setting up more stresses in the steel. These increased stresses possibly account for the slight increase in hardness as the steel is tempered to 200° F.

As the temperature rises above 200° F the ferrite and the cementite will separate. Microphotographs taken with the electron microscope of a steel tempered to 750° F. seem to indicate that the cementite separates out as a plate-like structure. (See Fig. 2) This micrograph shows the plate-like structure and also small spherical particles that have broken away from the plate-like cementite. A photomicrograph (See Fig. 3)

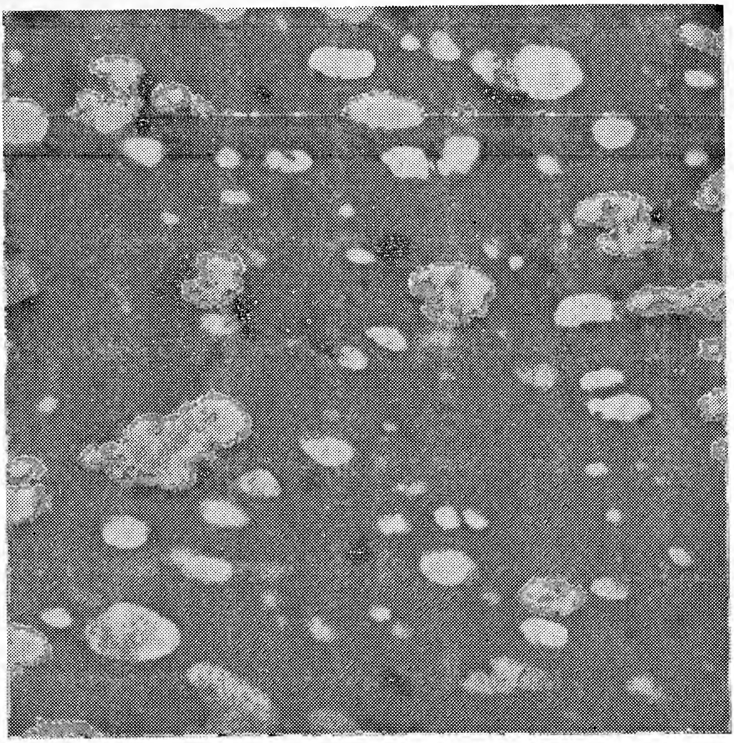


FIG. 3. STEEL TEMPERED TO 1250° F

taken of the same steel but tempered to 1250° F. shows that the entire plate-like structure has broken up into spherical particles. This is called spheriodized steel. This spheriodized steel has a hardness just above that of a full annealed steel.

Spheriodized steel.—Brinell 207 — Tensile strength 100,000 psi.

In our use of the electron microscope we were not able to get microphotographs of martensite. The reason may be that martensite is so uniformly hard that it etches very lightly so that a replica of the surface of the steel did not have a varied enough surface to show any contrast. To get a microphotograph of steel with the electron microscope it is necessary to transfer a replica of the surface of the steel to a film of some colloidal substance not over 10 millimicrons in thickness. This is extremely hard to do, hence many hours of work trying to get replicas of a hardened and tempered steel resulted in very few good photomicrographs.

Whenever we master the art of getting good replicas of the surface of a steel we shall know more about the structural form of the cementite in steel and more about the manner in which it is distributed in the steel. With this information we shall learn new ways in which we can control the microstructure of a steel and then we can produce a steel with any desired combinations of the physical properties within the natural limits of the steel involved.

RADIO SOUNDING OF THE ATMOSPHERE

ROY E. WILSON
Abilene Christian College
(Collegiate Section)

Great strides have been made in recent years in sounding the atmosphere, mainly since 1930. Prior to that time various procedures were tried in seeking an accurate and practical way to get measurements of temperature, relative humidity, pressure, wind direction, and wind velocity in the atmosphere.

Among these procedures were the use of kites, airplanes, and man-controlled balloons to carry the necessary measuring instruments aloft to make the measurements. All of these procedures succeeded in varying degrees, but with all there were severe limitations. In the use of kites, the altitude was very limited. Airplanes were often unable to take off or fly at times when the data were critically needed. This was especially true during severe frontal activity. And, of course, man operated and controlled balloons were too expensive and impractical.

Since 1938, the main work has been in perfecting the measuring instruments and the necessary radio equipment to transmit the data from its source to observers on the ground. During the war years, a great stride was made when directional antennas were perfected to the extent that the course of the balloon and the sounding equipment could be followed and sufficient data secured to permit very accurate determination of wind direction and velocity to extreme heights regardless of the weather.

Present day demands for weather data are such that observations all over the world are made simultaneously, and the collection and evaluation of these data must be made as quickly as possible. Weather information, just like news, must be up to date to be of greatest value. And, of course, measurements of the elements of weather in the atmosphere are just as necessary as on the surface.

Today, soundings are made at approximately 75 stations in the continental United States, 15 stations in the territory of Alaska, from weather ships at sea, and from other outlying stations. These observations are made twice daily and all stations make their releases for the soundings as nearly simultaneously as possible. In less than 3 hours from the time the ascensions begin, the data resulting from the soundings are available in every forecasting center in the United States—at least the data up to the 400 millibar pressure level.

The essential features of the equipment used in radio sounding today are as follows: A free balloon is used to lift through the atmosphere a small assembly, consisting of a pressure unit, a temperature element, an electrical hygrometer, a switching device, a battery, and a very small and compact radio transmitter. This assembly is capable of measuring accurately and transmitting signals equivalent to these measurements of temperature, humidity, and pressure at all altitudes up to the bursting-altitude of the balloon.

These signals are transmitted by radio at a rather high frequency and are picked up at the ground stations by means of high frequency receivers. With certain modifications, radio directional antennas can be used, in which case wind data are secured along with the other elements. These signals are then put through a frequency meter which, in a sense, evaluates them; they are then printed in graph form by means of an automatic recorder. This graphical recording is computed and evaluated on the basis of the relationship between frequency and surface temperature, and frequency and humidity as set up and calibrated just prior to the release of the equipment. Adiabatic charts are then drawn from these data; and from the charts, significant information is taken, such as the lapse rate, isothermal layers of air, temperature inversions, humidity values and changes, the freezing level, icing areas, and the pressure, temperature, and humidity at specific levels.

If the sounding is made in conjunction with directional antennas, the wind velocity and direction at all levels is also computed and evaluated. All of this information is then put in message form using a number code, the purpose of which is to conserve space and transmission time. It is transmitted to the regional forecasting centers and other agencies, where the data are replotted on pseudo-adiabatic charts and are used by meteorologists in formulating their forecasts as to the future trends of the weather in any given locality. Also, this information is used in planning aircraft operations and for obtaining corrections for the effects of the wind and the density of the air on artillery fire and guided missiles.

I shall now present the components of the sounding equipment in more detail. The instruments sent aloft with the balloon are a transmitter, a battery, a modulator, an antenna, and a parachute.

The Modulator consists of a temperature element, an electric hygrometer or humidity element, a pressure unit, and the necessary relays, wiring, etc.

The Temperature element is a ceramic resister which can be easily clipped into the circuit when needed. Its range of measurement is from 60° to 90° C., and its accuracy is + or – 0.5° C.

The Humidity element is a thin plastic strip ¾" wide and 5" long, which is coated with a gelatinous film containing a hygroscopic salt and each edge is silvered and serves as an electrode. The element is placed in a clip which plugs into the Modulator. The resistance of this element varies inversely with humidity of the air. It is designed to indicate relative humidity over the range between 15% and 100% and its accuracy is + or – 8% above 0° C. and + or – 12% below 0° and down to about –30° C. Below –30° C., relative humidity ceases to be of much practical importance. In fact, there is no good practical way to determine humidity, even in surface observations, below –30° C.

The Pressure unit consists of a pressure responsive capsule (aneroid cell) assembly connected to a level system which moves an electrical contact over a commutator. The commutator is made up of conducting segments separated by insulating segments. The conducting segments are so arranged that every 5th one is connected into the reference circuit; the others are connected into the humidity circuit. When the contact point is on an insulated segment the temperature circuit is doing the modulating. The conducting segments for humidity switch in the humidity circuit by means of a relay.

Each pressure unit is calibrated in a pressure chamber at the factory and an individual calibration curve is drawn. This calibration curve is later used during the sounding to determine the indicated pressure at any given point in the ascension. This will be further explained after the transmitter is introduced.

The Transmitter has two tubes. One tube is for the relaxation oscillator or modulated oscillator which is controlled by the amount of resistance in the grid circuit which, in turn, is controlled by the temperature or humidity in their respective circuits or by the reference circuit. The reference circuit is at constant resistance and hence gives a given constant oscillation which, when received and recorded at the ground station, provides a means of counting contacts through which the contact point has switched and thereby a means of ascertaining the pressure.

The tuned circuit resonates at approximately 1 megacycle per second. When a reference segment is closed, the time constant between the resistance and capacitance of that circuit is such that the oscillation of the tube is interrupted at an audio rate of approximately 195 cycles per second. As the resistance of the temperature and humidity circuits varies, the time constant will also vary to produce interruptions between approximately 8 and 180 cycles per second. The ground equipment makes use of these interruptions to convert the signal into graphic form.

The second tube in the transmitter acts simply as a carried oscillator with a nominal frequency of 397 megacycles, but it can be varied between 387 and 407 megacycles.

The transmitter is equipped with a silver-coated single rod antenna.

The power is furnished by a battery pack composed of one A-unit and three B-units.

The A-Unit is a small 3½" x 2" x 1", 3 cell, lead acid type battery with a nominal voltage of 6.3 V and current drain of 250 milliamperes. The weight is 137 grams.

The B-Unit is the same size as the A-Unit, but has 18 cells, lead acid type, with a nominal voltage of 36V, and a current drain of 30 milliamperes. Each one weighs 155 grams. The electrolyte used is 1.35 specific gravity sulfuric acid.

The complete assembly, including cord and parachute, weighs approximately 1650 grams.

The ground components are a high frequency receiver, a frequency meter, and an automatic recorder. During a sounding the signals are picked up by the receiver which is connected to the antenna through a co-axial cable. The signal is measured by the frequency meter by converting the output of the receiver to a pulsating direct current which is proportional to the audio frequency of the receiver output. The value is indicated on a dial by means of a pointer, and it appears in numbers of bi-cycles. This frequency meter is directly connected to another frequency indicator in the automatic recorder. This meter is situated between a light source and a photoelectric tube.

There is also an automatic paper feed that feeds out continuous graph paper which has 100 divisions from left to right representing 0 to 100 bi-cycles.

The photoelectric system is part of a rotating scanning device which is synchronized with a rotating cylinder and tapper bar assembly. On the rotating cylinder is a raised ridge. When the frequency meter pointer interrupts the light to the photo tube, a coil is energized which causes the tapper bar to tap against the rotating cylinder. In between he two is the graph paper and an inked ribbon. The tap will cause a printed dot on the paper and the print will correspond to the number of bi-cycles as indicated by the frequency meter. This gives an automatic graph of the temperature, humidity, and pressure which is being currently measured by the modulator as it ascends through the atmosphere.

The height of the sounding depends on the ability of the balloon to withstand cold temperatures and to expand. The balloon used is a 350 gram molded sphere. When inflated with hydrogen or helium it is about 5 feet in diameter. It is designed to expand to approximately 16 feet in diameter before bursting. Synthetic rubber, such as neoprene, which has been used for the past several years is not as satisfactory as the pure latex balloons used prior to the war. The bursting altitude varies directly with the height of the Tropapause. The "Tropapause" is a term applied to the region between the Tropasphere and the Stratosphere where a minimum temperature is reached. At Yakutat, Alaska, the altitude of the Tropapause for the 3 summer months in 1945 averaged approximately 12,000 feet higher than it did during the previous 3 winter months. The soundings averaged approximately 15,000 feet higher during the summer months than during the winter months.

The highest sounding during the year of 1945 at the Yakutat, Alaska station was to 93,200 feet (approximately) and the pressure was 19 millibars. The next highest sounding was to a height of 92,400 feet and 21 millibars pressure. These two altitudes are just above the extreme altitudes possible at that northern latitude for neoprene rubber balloons of the type currently in use. The latitude enters into the consideration because the Tropapause is lowest at the poles and highest at the equator. This is true because of temperature differences in the lower atmosphere and the effects of the earth's rotation.

It was found that as much as 15% increase in altitude of the bursting point of the ballons could be achieved by treating the balloons by immersion in water at 80° C. for a period of 30 minutes just prior to inflating them, and, by keeping the interval between the inflation and the release to a minimum.

The coloring of the surface of balloons with dark liquids (such as ink) in order to increase the absorption of heat from the sun seemed to be of little or no value. Long exposure of neoprene balloons to strong sunlight proved very harmful to the rubber in that it decreased its ability to expand.

The greatest difficulty in making soundings and getting them completed on schedule was experienced in coping with the icing problem. The balloons were frequently iced down. This was caused by the balloon passing through super-cooled moist air. The ice accumulated on the balloon and instruments to the extent that the lift of the balloon became nullified and the assembly would descend. Frequently, after it had descended below the freezing level, the ice would melt off before the assembly reached the ground and it would again ascend. Sometimes this second ascension would penetrate the icing layer and successful sounding were accomplished without additional releases. However, if the weight of the ice forced the balloon to the ground, a second release was made, using a balloon inflated with more gas to give increased lift. On one occasion, icing and de-icing occurred three times and on the fourth ascent, the balloon penetrated the ice layer.

High winds are a hazard to making releases due to the fragileness of the instruments. However, once the balloon and instruments are airborne, the wind does not affect the sounding, provided the station is properly situated with regard to mountains and massive steel obstructions which could affect the radio reception. Successful releases have been made in winds blowing in excess of 60 miles per hour at land stations. Releases can be made in higher winds at sea by having the ship run with the wind. Releases in 30 and 40 M.P.H. winds are routine at many stations.

It is now possible to make soundings by radio from airplanes. High altitude craft drop instruments by parachute, similar to those I have described. As the slow descent takes place the signals are picked up in the plane and the data are secured as by standard procedure, except in reverse. This method is especially valuable for military purposes and for securing data from over the oceans where full time operation of weather ships is not feasible. It is especially valuable in diagnosing and studying the nature of hurricanes in the Gulf of Mexico and other similar areas.

Without radio sounding of the atmosphere, meteorology would be set back to its status of 50 years ago. Just as a doctor must know what is taking place inside the body, so the meteorologist must know what is taking place in the atmosphere. Radio soundings give him the data he needs.

THE REPTILES AND AMPHIBIANS OF THE SIERRA VIEJA RANGE OF SOUTHWESTERN TEXAS

DAVID L. JAMESON AND ALVIN G. FLURY
University of Texas

INTRODUCTION

The herpetological fauna of the Sierra Vieja Mountains of southwestern Texas has not previously been studied. This mountain range lies in the Chihuahuan biotic province as limited by Dice (1943). Little attention has been given to the herpetological fauna of this province in Texas and no study of the ecological distribution of reptiles and amphibians has previously been made. The reptiles and amphibians of the Big Bend region of Texas were studied by Schmidt and Smith (1944). The reptiles and amphibians of northern Coahuila, Mexico, were studied by Schmidt and Owens (1944). Smith and Taylor (1945) have reviewed the snakes of the adjoining regions of Mexico. Strecker (1909) has surveyed the reptiles and amphibians of Brewster County, Texas. Brown (1903) lists 48 species from Pecos, Texas.

The present report concerns part of a survey of the ecological distribution of the vertebrates of the Sierra Vieja region. The mammals have been treated by Blair and Miller (1949) and the summer resident birds have been studied by Phillips and Thornton (1949). The physical and vegetational environment of the region has been described by York (1949).

Herpetological field collections were made by A. L. Carroll, T. M. Burke, and the authors with the assistance of the 20 other members of the survey party. The period of June 3 to July 9, 1948 was spent in the field. Some specimens were collected in July, 1947 by W. F. Blair, C. E. Miller, Jr., and D. G. Walker, and some were collected in April, 1948 by Blair and Miller.

We are indebted to C. E. Miller, Sr. and Mr. Roosevelt for permission to work on their ranches in the Sierra Vieja region and to Mr. Duncan for the privilege of the use of his land near Porvenir, on the Rio Grande.

The writers are indebted to Dr. W. F. Blair for his constant advice and encouragement.

ECOLOGICAL RELATIONSHIPS

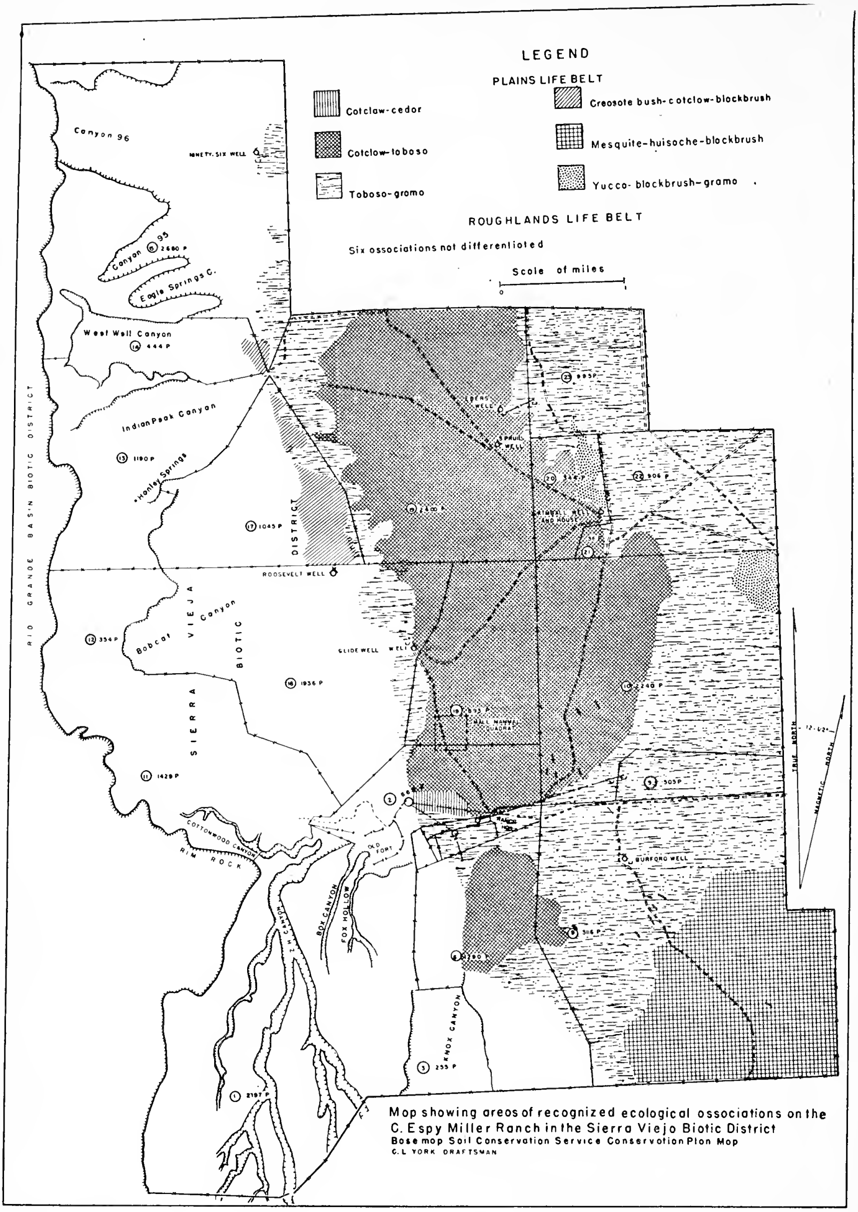
The area under consideration is in the northern part of the Chihuahuan biotic province of Dice (1943) and lies at the western side of the Valentine plain. The descriptions and limits of the biotic districts, life belts and associations have been presented by York (unpublished). These divisions are based on the vegetation as well as on the mammals, birds, reptiles and amphibians.

SIERRA VIEJA BIOTIC DISTRICT

The Sierra Vieja biotic district is named for the mountains of that name which trend north-south along the northwestern edge of Presidio County. The rim rock at the western side of the mountains divides the districts from the Rio Grande Basin biotic district. The mountains themselves are considered as the Roughland life belt as distinguished from the Plains life belt on the Valentine plain. The mountains were formed by tilted fault blocks covered by Tertiary volcanoes before faulting. They are rather low which accounts for the smaller amount of rainfall and the absence of the high altitude associations of the Davis Mountains. The Valentine plain extends northeast to the base of the Davis Mountains and is comparable to the Plains life belt of the Davis Mountains as described by Blair (1940). Our work was done chiefly on the C. Espy Miller ranch at about the center of the range.

PLAINS LIFE BELT

Seven associations were definable in the Plains life belt in the general vicinity of the Miller ranch. Another, the yucca—tobosa association, occurred along the road from Valentine to Marfa. This life belt was characteristically sandy but two associations, which were quite rocky, were found near the Roughland life belt. The ecological distribution of the reptiles and amphibians in the Plains life belt, as evidenced by the specimens we collected, is shown in Table I. A short discussion of each association follows:



Map showing areas of recognized ecological associations on the C. Espy Miller Ranch in the Sierra Viejo Biotic District
Base map Soil Conservation Service Conservation Plan Map
C. L. YORK DRAFTSMAN

YUCCA—TOBOSA ASSOCIATION

This association is not listed by York (unpublished) because no active collecting was done there. The specimens collected in this association were picked up on the highway between Marfa and Valentine. Several other coachwhips **(Coluber flagellum testaceus)** were seen but escaped into rock filled culverts.

BLACKBRUSH—CREOSOTE—BUSH ASSOCIATIONS

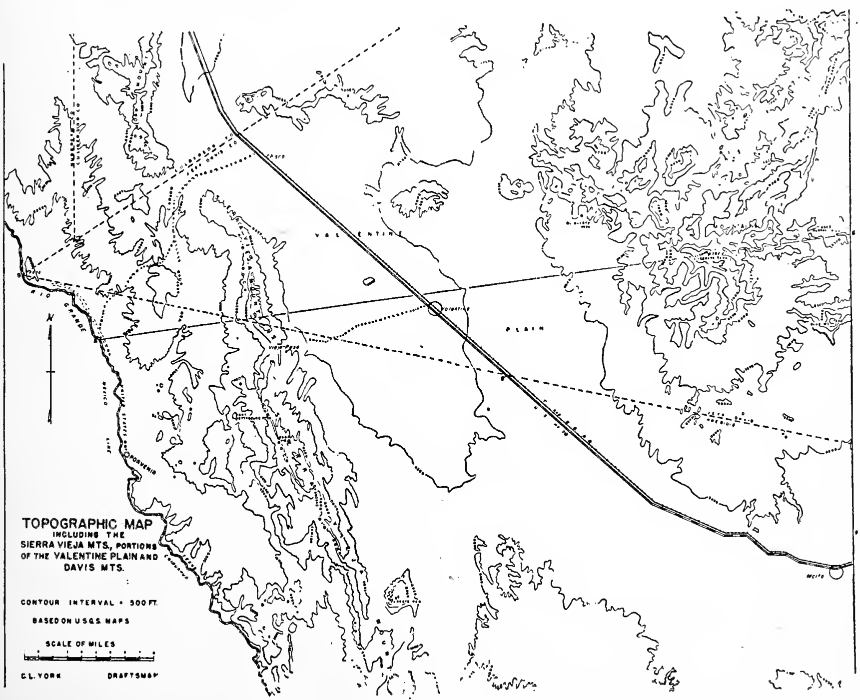
The blackbrush—creosote—bush association occurred on a slightly raised hill about three miles east of the Miller ranch house. The soil was calcareous with much gravel and small rock but was not considered a rocky plains association because of its distance from the Roughland belt, the absence of large rocks and the absence of Roughland belt species.

YUCCA—BLACKBRUSH—GRAMA ASSOCIATION

This association was found about four miles northeast of the Miller ranch house. Reptiles and amphibians seemed to be rather scarce and relatively little work was done in the area.

CATCLAW—TOBOSA ASSOCIATION

The catclaw—tobosa association, as described by York (unpublished), occupied almost all of the alluvial fan areas except for the catclaw—cedar association at the mouths of the major canyons. Because the presence or absence of rocks seemed to be the limiting factor concerning reptiles and amphibians, the rocky parts of the catclaw—tobosa association close to the canyon mouths are here included in the catclaw—cedar association. The remainder of the alluvial fans were predominantly sandy with scattered areas of small rock. The catclaw bushes increased in size and density away from the canyon mouths and furnished good rodent cover. None of the reptiles or amphibians was found to be restricted to the association, but **Holbrookia maculata, Phrynosoma**



cornutum and **Cnemidophorus perplexus** reached their highest abundance here and were considered characteristic of the association.

TOBOSA—GRAMA ASSOCIATION

This association was predominantly sandy, but where it was found adjacent to the Roughland belt areas of small rock were scattered through it. Some yuccas and a few bushes occurred in the association. According to our collections the following species were limited to the association: **Bufo insidior, Ambystoma tigrinum, Kinosternon flavescens, Tantilla atriceps, Crotalus scutulatus** and **Crotalus viridis**. The first three of these were found only in or near lakes in the association.

MESQUITE—HUISACHE—BLACKBRUSH ASSOCIATION

This association occurred in an area about one mile southeast of the Burford well. It was quite rocky, but without large rocks, and lay about midway between the mountains and a mountainous outlier in the Plains. Reptiles were apparently scarce in this association. None of the species found there was restricted to the association.

CREOSOTE—BUSH—CATCLAW—BLACKBRUSH ASSOCIATION

This association was found adjacent to the mountains in the vicinity of Roosevelt well. The area was quite rocky with little grass but with many desert shrubs under which rodent burrows were common. A total of 14 species was found in this association. Eight (57.1%) of these species were considered Plains forms, two (14.3%) were considered as equally divided between Plains and Roughlands and four (28.6%) were considered Roughland forms. In the Sierra Vieja biotic district, **Cnemidophorus grahamii** reached its peak abundance here and **Crotalus atrox** seemed to be restricted to the association.

CATCLAW—CEDAR ASSOCIATION

The catclaw—cedar association, as described by York (unpublished), occurred only in small areas at the mouths of the major canyons. Because the presence or absence of rocks seemed to be the limiting factor for reptiles and amphibians, the rocky parts of the catclaw—tobosa association close to the canyon mouths are here included in the catclaw—cedar association. Characteristic species were **Coleonyx brevis, Holbrookia texana, Cnemidophorus gularis** and **Cnemidophorus perplexus. Bufo punctatus** and **Rana pipiens** were caught near tanks and rain pools in the association. The association seemed to be a region of marked overlap between the faunas of the Plains life belt and of the Roughland life belt. None of the species found there was restricted to the association. Nine species (36.0%) seemed to be primarily Plains forms, one species (4.0%) was considered as equally divided between the Plains and Roughland life belts, and 15 species (60.0%) seemed to be primarily Roughland forms.

ROUGHLAND LIFE BELT

Six associations were distinguishable in the Roughland life belt. All of them were very rocky and there was ample cover for reptiles. Free water occurred as pools or short streams of running water in the major canyons. The distribution of the reptiles and amphibians in the various associations, as shown by our records, is given in Table II. A short discussion of each association follows:

STREAM BED ASSOCIATION

The stream bed association was found in the bottom of all major canyons and many branch canyons throughout the mountains. Small scattered pools of water were formed in potholes in the bed rock in many places and running water from springs was found in Z H Canyon. **Hyla arenicolor, Diadophis regalis** and **Trimorphodon vilkinsonii** were found only in this association. **Thamnophis eques** reached its greatest abundance here and was largely limited to this association. **Urosaurus ornatus** and **Cnemidophorus gularis** were also common species here.

CATCLAW—GRAMA ASSOCIATION

This association occupied most of the mountain slopes and flats lying between the rock bluffs and the stream beds. Rock slides of variable size were scattered throughout the association. **Lampropeltis alterna** and **Tantilla nigriceps** were found only in this association. The most common reptiles found here were **Cnemidophorus gularis** and **Urosaurus ornatus**.

GRAMA—BLUESTEM ASSOCIATION

This association occurred in scattered areas along the eastern front of the mountains. In geographic position and probably in herpetology it was similar to the catclaw—grama association. Comparatively little collecting was done in the association which, together with its small extent, may account for the small list of species.

ROCK BLUFF ASSOCIATION

The rock bluff association occurred on the precipitous rim rock at the edges of the mesa. These bluffs were almost continuous on the western edge of the mountains but were broken by passes on the eastern side. The bluffs usually extended only a short way down to meet the mountain slopes, but in some instances they fell off directly from the mesa to the stream bed. The association could be collected in only along its edges, which accounts for the small list of species recorded from it.

LECHUGUILLA—BEARGRASS ASSOCIATION

The lechuguilla—beargrass association occurred over most of the tops of the tilted fault blocks of the mountains. The soil was usually shallow and very rocky. Less collecting was done here than on the lower reaches of the mountains because of the relative inaccessibility of the mesa. **Cnemidophorus gularis** was the most characteristic species of the mesa top.

HUISACHE—LECHUGUILLA ASSOCIATION

Only one rather small area of this association was found. It was on top of the mesa almost completely surrounded by the lechuguilla—beargrass association. The only specimen taken, a **Salvadora hexalepis,** was the only specimen of its species from the mesa top and one of two specimens from the Roughland life belt.

RIO GRANDE BASIN BIOTIC DISTRICT

The Rio Grande Basin biotic district lies to the west of the Sierra Viejas along the river. Presumably the area was once covered by an internal drainage lake and the topographic relief is not so great as in the mountains but more pronounced than on the Valentine plain. The area was visited on four short collecting trips totalling about six and one-half days by six or seven members of the field party. The four species of amphibians and 11 species of reptiles collected there by us do not furnish a complete list for the district. The distribution of the specimens in our collection from the various ecological associations is given in Table III. Five species were found in this district which were not found in the Sierra Vieja biotic district. These include:

Bufo cognatus
Bufo compactilis
Uta stansburiana
Cnemidophorus tessellatus
Elaphe laeta

A short discussion of each of the five associations found in the district follows:

OCOTILLO—CREOSOTE—BUSH ASSOCIATION

The ocotillo—creosote—bush association occurred over most of the Rio Grande Basin biotic district from the western rim rock of the Sierra Vieja Mountains almost to the Rio Grande. Less collecting was done here than along the river. The association was made up mostly of ridges of water worn rocks and gravel covered by more or less thick stands of ocotillo, creosote bush and yuccas. A whipsnake (**Coluber taeniatus**) was the only form found here and not in other associations of the district, and it was also found in the Sierra Vieja biotic district.

CATCLAW—CREOSOTE—BUSH ASSOCIATION

This association was found in the low sandy washes which drained the higher ocotillo—creosote—bush association. The association was rather sharply separated from the ocotillo—creosote—bush association along the bases of the ridges and from the salt cedar—mesquite association at the edge of the flood plain of the river. Fairly large catclaw and mesquite bushes were found along the central drainage ditches and smaller creosote bushes and mesquites were found on the dryer flats of the association. **Uta stansburiana** seemed to be restricted to the association. A racerunner (**Cnemidophorus tessellatus**) reached its highest abundance here and was considered characteristic of the association.

SALT CEDAR—MESQUITE ASSOCIATION

The salt cedar—mesquite association extends along the banks and flood plain of the Rio Grande and varies from 50 to 200 yards wide on the Texas side. The trees were very thick and in some places were impenetrable. The plains toad (**Bufo cognatus**) and a rat snake (**Elaphe laeta**) were found only in this association. The spadefoot (**Scaphiopus Hammondii**) and a tree lizard (**Urosaurus ornatus**) were found only in this association of the district, but they were also taken in the Sierra Vieja biotic district and probably occurred in other associations of the Rio Grande basin. Three species, **Scaphiopus hammondii, Cnemidophorus grahamii** and **Cnemidophorus tessellatus,** were found in the relatively open edges of the association near the catclaw—creosote—bush association.

OIL FIELD ASSOCIATION

This association consisted of a cleared field in the Rio Grande flood plain and was surrounded by the salt cedar—mesquite association. The association was distinguished chiefly by its bird population. The single **Thamnophis marcianus** which we collected there was the only example of its species from the Rio Grande basin but others were taken in the Sierra Vieja biotic district and the species probably occurred throughout the salt cedar—mesquite association.

COTTONWOOD ASSOCIATION

The cottonwood association consisted of scattered large cottonwood trees surrounded by the salt cedar—mesquite association. Like the old field association it was distinguished chiefly by its bird population. The single **Sceloporus undulatus** from this association was collected on the trunk of one of the large trees and was the only example of its species collected from the Rio Grande basin. Other specimens were seen on other cottonwood trees but could not be caught.

ANNOTATED LIST OF SPECIES

A total of 1671 herpetological specimens was recorded from the areas studied during the course of the summer field work. This collection includes 53 species: ten species (343 specimens) of anurans; one species (171 specimens) of urodeles; two species (28 specimens) of turtles; 16 species (925 specimens) of lizards; and 24 species (204 specimens) of snakes. This list includes two species of snakes collected by Blair, Miller, and Walker in 1947 and a probable call record for one species of frog. All of the specimens collected are deposited in the Texas Natural History Collection at the Department of Zoology, The University of Texas.

AMPHIBIA

SALIENTIA

Scaphiopus couchii Baird. These toads were probably restricted to the associations of the Plains belt. Four specimens were taken on the Miller ranch, one from the catclaw—tobosa association, one from the creosote—bush—catclaw—blackbrush association and two from the catclaw—cedar association. One specimen was collected in the salt cedar—mesquite association of the Rio Grande Basin district. Three others were caught but lost, two from the salt cedar—mesquite and one from the catclaw—creosote—bush associations of the Rio Grande Basin district. All were collected at night. Two taken during a light rain were near shallow ponds of rain water, but the others were active on dry nights and were not in the near vicinity of water. No calls of this species were heard and their breeding had probably been completed during the heavy rains which fell the week before we reached the ranch.

Scaphiopus hammondii Baird. This species occurred mostly in the associations of the Plains belt, but it did enter the Roughland belt. Twenty specimens were collected. Ten were taken in the tobosa—grama association of the Plains belt. Two were caught in the stream bed and one in the catclaw—grama association of the Roughland belt. Seven newly transformed young were taken from rain pools in the salt cedar—mesquite association of the Rio Grande Basin district. Two other specimens were taken by Miller from the tobosa—grama association in 1947. All specimens were taken while active at night except the young from the Rio Grande Basin. Most of the toads were found near rain water ponds during or immediately after rains, but a few were found on dry nights away from any standing water. Calls were not heard, and the breeding season was probably finished during the rains shortly before we got to the ranch.

Bufo cognatus Say. Only one specimen of this toad was collected. It was found in a cattle watering trough one mile south of Porvenir in association with eight **Bufo compactilis.** These toads were apparently stranded in the trough when they went to the water as a breeding site. The trough was in the salt cedar—mesquite association of the Rio Grande Basin district.

Bufo compactilis speciosus Girard. Twenty-five specimens were collected, all in the Rio Grande Basin district. Sixteen of these were newly transformed young taken from small rain pools in the salt cedar—mesquite association five miles north of Porvenir. Eight adults were taken from a cattle watering trough in the same association one mile south of Porvenir. One adult was collected at night in a dry wash of the catclaw—creosote—bush association five miles north of Porvenir. The adults seem to agree with Smith's (1947) description of the subspecies **speciosus.**

Bufo insidior Girard. A total of 179 specimens was collected, all calling in chorus from rain pools and small ponds, in the tobosa—grama association. On the night of June 3, 153 specimens were collected following an early evening shower. The others were taken on rainy nights. Numerous clasping pairs were found.

Bufo punctatus Baird & Girard. Forty-eight specimens were taken on the Miller ranch, 38 from the Plains belt and 10 from the Roughland belt. Of those from the Plains belt, 30 were taken from a chorus around a tank in the catclaw—cedar association, three were taken from tanks in the tobosa—grama association and two from the catclaw—tobosa association. Several clasping pairs and single females were found on June 3. Three specimens were collected from the creosote—bush—catclaw—blackbrush association at the edge of cattle watering troughs. Those from the Roughland belt are from the following associations: catclaw—grama, six; stream bed, four. None of these was calling or clasping, and some of them were taken on clear, dry nights.

Hyla arenicolor Cope. Thirteen adults and several larvae were collected from the stream bed association of the Roughland belt. Small isolated pockets in bed rock in the middle and upper reaches of Z H and Box Canyons were filled with rain water. Most such pockets contained large numbers of tadpoles which were predominantly of **Hyla arenicolor.** Most of the adults were found in the direct sun on large boulders or on solid rock stream banks within fifty feet of a pond. Their color blended well with the lichen covered rock. Many of the **Thamnophis eques** collected near these ponds were gorged with the larvae of these frogs. No calls were heard even on the rainy nights. One specimen was caught by Blair in April, 1948 at dusk on dry rocks at the mouth of Z H Canyon.

Syrrhophus gaigeae Schmidt & Smith. Calls of **Syrrhophus** were heard frequently on rainy nights from rock bluffs and rock slides of the Roughland belt. Although we could make close approach, we were unable to find the animals responsible for the calls.

Rana pipiens berlandieri Baird. These frogs occurred rather commonly in both the Plains and Roughland belts, apparently in nearly equal numbers. Surprisingly, Schmidt & Smith (1944) reported them as not occurring in the mountain canyons of the Chisos Mountains. Specimens were taken by us from the near vicinity of the tanks and artificial lakes of the Plains belt in the following associations: catclaw—cedar, 15; tobosa—grama, one. Fourteen specimens from the Roughland belt were all taken near or in ponds in the stream bed association. One **Thamnophis eques** was found trying to swallow a large **Rana pipiens** and another frog was found with two leeches attached to it. Only a few larvae of this species were seen. These were in the larger ponds and running water of the stream bed of Z H Canyon.

Microhyla olivacea (Hallowell). This species occurred in both the Plains and Roughland belts. Those from the Plains belt totaled three from the catclaw—cedar and nine from the tobosa—grama association. All were found calling on rainy nights from tanks or ponds. Of the Roughland belt specimens, eight were from the stream bed and two from the catclaw—grama association. The latter were found on a rainless night and were not in the vicinity of water. All stream bed specimens were taken on a rainy night while calling from a small pool, except for two which were found calling in midafternoon of a cloudy day.

URODELA

Ambystoma tigrinum mavortium Baird. A total of 171 larvae of this species was seined from an artificial lake about two miles north of the Miller ranch house. The lake was about ten years old, ranged from three to five feet deep, was very muddy, and was said to contain water throughout most years of normal rainfall. The area surrounding the lake was in the tobosa—grama association, and rocks, logs and other surface cover were lacking. In July, 1947, several hundred specimens were collected from this and smaller nearby lakes by Blair, Miller and Walker. These specimens show reduction of the external gills and some development of the adult dorsal pattern, indicating that transformation probably does occur. **Kinosternon flavescens, Thamnophis marcianus,** and **Thamnophis eques** (one specimen) were collected at this lake. It seems probable that these reptiles feed on the salamanders.

REPTILIA
CHELONIA

Kinosternon flavescens (Agassiz). Four specimens were seined from the same lake from which **Ambystoma tigrinum** was taken. Eight others were taken in July, 1947, by Blair, Miller and Walker from several small lakes in the same area. These turtles were probably restricted to the water tanks of the Plains belt. They probably preyed on the **Ambystoma** larvae.

Terrapene ornata (Agassiz). This species occurred in all associations of the Plains belt but was not found in the Roughland belt. Specimens were taken in the following associations: catclaw—cedar, one; creosote—bush—catclaw—blackbrush, three; blackbrush—creosote—bush, two; tobosa—grama, three; catclaw—tobosa, four. Three others were taken in the yucca—tobosa association a few miles west of Marfa.

LACERTILIA

Coleonyx brevis Stejneger. This species was apparently restricted to rocky areas. Twenty-one specimens from the Plains belt were all taken in the catclaw—cedar association. Of 16 from the Roughland belt, eight were from the catclaw—grama, seven from the streambed, and one from the lechuguilla—beargrass association. All except one, found under a large rock in the catclaw—cedar association, were collected while active at night.

Cotaphytus collaris baileyi Stejneger. The collared lizard occurred in areas of scattered rock in both the Plains and Roughland belts. Three were caught in the Roughland belt of the Miller ranch. One was taken in the lechuguilla—beargrass, one in the catclaw—grama and one in the stream bed association. In the Plains belt six were caught in the catclaw—cedar association, one in the catclaw—tobosa association and one in the creosote—bush—catclaw—blackbrush association. Two were collected from the lechuguilla—beargrass association about 12 miles southwest of Valentine, and one was collected in the catclaw—grama association of a Roughland outlier about seven miles southwest of Valentine.

Holbrookia maculata aproximans Baird. Sixty-one specimens were collected on the Miller ranch, all from the Plains belt. These lizards were most common in sandy areas, but a few were taken near the edges of the rockier catclaw—cedar association where they were replaced by **Holbrookia texans.** Specimens were taken in the following associations: catclaw—cedar, one; creosote—bush—catclaw—blackbrush, one; mesquite—huisache—blackbrush, seven; tobosa—grama, 14; catclaw—tobosa, 38. These lizards were found active during most daylight hours. One was found on an ant bed one night about 10 p.m. When approached, almost every specimen would run to the nearest catclaw or yucca, and many escaped down kangaroo rat **(Dipodomys merriami)** burrows. Three of the specimens from the tobosa—grama association were taken from a prairie dog **(Cynomys ludovicianus)** town about 10 miles north of the Miller ranch house. These, as well as other specimens from a prairie dog town 10 miles west of Ft. Davis, Jeff Davis County, Texas, have a distinct pink coloration. This color was found on only one specimen from the Miller ranch. There is considerable variation in the dorsal pattern of this species. Many pairs as well as single animals escaped down prairie dog holes before they could be shot. A partly digested specimen was found in the alimentary tract of a garter snake (**Thamnophis marcianus**).

Holbrookia texana (Troschel). Fifty-three specimens were collected, all from the Miller ranch except two from the catclaw—creosote—bush association of the Rio Grande Basin district five miles north of Porvenir. In the Sierra Vieja district these lizards seemed to be more or less restricted to rocky areas. In the Roughland belt they were taken in the following associations: catclaw—grama, 10; stream bed, eight. In the Plains belt they were taken in the following associations: catclaw—cedar, 30; creosote bush—catclaw—blackbrush, two; catclaw—tobosa, one. Two specimens from the catclaw—grama association were seen eating winged termites which had emerged during and after a light afternoon shower.

Sceloporus poinsettii Baird & Girard. Nineteen specimens were collected from rock crevices in the Sierra Vieja District. Two specimens were found in cracks of large boulders in the transitional catclaw—cedar association of the Plains belt. The others were from the Roughland belt: nine from the stream bed, six from the catclaw—grama and two from the rock bluff association. At only one time did we see this species active.

Sceloporus undulatus consobrinus Baird & Girard. This species was found chiefly on large yuccas or catclaw bushes in the Plains belt. One specimen was taken in the Roughland belt, in the catclaw—grama association. Eleven specimens were taken from the following associations of the Plains belt: catclaw—cedar, six; catclaw tobosa, three; creosote bush—catclaw—blackbrush, one; and tobosa—grama, one. One specimen was taken from a large cottonwood tree in the Rio Grande Basin district five miles north of Porvenir.

Uta stansburiana stejnegeri Schmidt. Three specimens were collected in the catclaw—creosote—bush association of the Rio Grande Basin district five miles north of Porvenir. This species was not found in the Sierra Vieja district.

Urosaurus ornatus schmidti (Mittleman). This species was very common in the rocky areas of the Miller ranch. One specimen was taken from the salt cedar—mesquite association of the Rio Grande Basin district. In the Sierra Vieja district specimens were obtained in the following associations of the Roughland belt: lechuguilla—beargrass, seven; rock bluff, eight; catclaw—grama, 34; stream bed, 74; in the Plains belt, nine were taken in the transitional catclaw—cedar association. One specimen was seen eating a winged termite after an afternoon shower.

Phrynosoma cornutum (Harlan). Sixty-one specimens were collected from the Plains belt of the Sierra Vieja district. None was taken in the Roughland belt. The collection represents the following associations: catclaw—tobosa, 30; mesquite—huisache—blackbrush, 14; tobosa—grama, five; blackbrush—creosote—bush, five; catclaw—cedar, two; creosote—

bush—catclaw—blackbrush, two; and yucca—blackbrush—grama, two. Specimens were seen active during most daylight hours. Two were seen eating ants.

Phrynosoma modestum Girard. This species is almost restricted to the Plains belt in the Sierra Vieja district. Fourteen specimens are from the following associations of the Plains belt; catclaw—tobosa, nine; catclaw—cedar, three; mesquite—huisache—blackbrush, one; and blackbrush—creosote—bush, one. Only one specimen was found in the Roughland belt, in the catclaw—grama association. Two were collected from the Rio Grande Basin district, one each from the ocotillo—creosote—bush association two miles northwest of Porvenir, and from the catclaw—creosote bush association five miles north of Porvenir.

Cnemidophorus grahamii Baird & Girard. This species occurred in about equal numbers in the Roughland and Plains belts of the Sierra Vieja district. On the Plains belt they were found in the following associations: creosote—bush—catclaw—blackbrush, 14; catclaw—cedar, four. The specimens from the Roughland belt were taken in the following associations: stream bed, 10; catclaw—grama, two; lechuguilla—beargrass, one. Nine specimens were taken in the Rio Grande Basin district five miles north of Porvenir. These were found only in the sandy areas, not on the rocky ridges. Three of these were in the salt cedar—mesquite association, and six were in the catclaw—creosote—bush association. One specimen on the Miller ranch was seen eating a scorpion.

Cnemidophorus gularis octolineatus Baird. This lizard was not found in the Rio Grande Basin district although it was a common form in the Roughland belt and the rocky parts of the Plains belt of the Sierra Vieja district. Thirty-seven specimens from the Plains belt were taken in the following associations: catclaw—cedar, 29; catclaw—tobosa, three; mesquite—huisache—blackbrush, three; tobosa—grama, two. In the Roughland belt 127 specimens were taken in the following associations: lechuguilla—beargrass, 36; catclaw—grama, 47; grama—bluestem, two; and stream bed, 42. There is only a slight overlap of the local range of this species with **Cnemidophorus perplexus** along the edges of the rocky associations of the Plains belt. Little difficulty was found in separating the two species, the **C. gularis** being distinguished by larger size, spots between at least some of the longitudinal lines, lack of a distinct (sharp-edged) mid-dorsal line, and lack of diffused blue color over the ventral surface. One specimen was seen eating a winged termite.

Cnemidophorus perplexus Baird & Girard. These small blue bellied lizards seemed to be strictly limited to the Plains belt in the Sierra Vieja district. They were most common in sandy areas. Two hundred and forty-three specimens were collected from the following associations: catclaw—cedar, 53; creosote—bush—catclaw—blackbrush, three; blackbrush—creosote—bush, eight; catclaw—tobosa, 174; tobosa—grama, one; yucca—blackbrush—grama, two; and mesquite—huisache—blackbrush, two. They were found active during all daylight hours and usually made for the nearest catclaw bush when frightened. Many escaped down rodent burrows under these bushes. Two were found in the gullet of a nestling roadrunner (**Geococcyx californianus**). The characteristic differences between this lizard and the young of **C. gularis** have been noted under the latter species.

Cnemidophorus t. tessellatus (Say). We found these lizards only in the Rio Grande Basin district and in the following associations: ocotillo—creosote—bush, one; salt cedar—mesquite, two; catclaw—creosote—bush, 49. These lizards were found active during all daylight hours except early morning. They were very wary and quickly ran toward small mammal burrows (**Dipodomys merriamii** and **Perognathus penicillatus**) under the bushes. Seldom could we approach a specimen closer than twenty feet and we had to shoot all specimens.

Eumeces brevilineatus Cope. Seven specimens were collected from the Roughland belt of the Sierra Vieja district. Five came from the stream bed, and two came from the catclaw—grama association. One ran into a pool and swam under water in an attempt to escape.

Eumeces obsoletus (Baird & Girard). Three specimens were collected from the catclaw—grama association of the Roughland belt, and one juvenile was taken in the catclaw—cedar association of the Plains belt. One specimen was seen in the stream bed association, but it escaped into a rock crevice. The species was probably restricted to rocky areas.

SERPENTES

Leptotyphlops humilis segregus Klauber. Two specimens were collected, active at about 10 p.m., one each from the stream bed and catclaw—grama associations. This species probably occurs throughout the Roughland belt and on the rocky areas of the Plains belt.

Diadophis r. regalis Baird & Girard. Two specimens were taken, active at mid-morning, in the stream bed association of Z H Canyon. This species was probably restricted to the rocky associations of the area. Because of the great variation within the genus it seems best to describe these specimens. Both are males and neither has a nuchal ring. The total length measures 522 mm. and 259 mm., tail length 78 mm. and 37 mm., ventrals 227 and 224, caudals 53 in both, scale rows 17-15-15 in both, supralabials 7-7 in both, infralabials 9-9 in the larger and 9-8 in the smaller, temporals 1-1-2 in both. In contrast to the type series of **D. r. blanchardi** Schmidt & Smith (1944) the present specimens have a higher ventral count, and they have two temporals in the third row instead of one.

Heterodon nasicus kennerlyi Kennicott. We have two specimens of this species, both from the Miller ranch. One specimen, a female, was collected by Miller in 1947 from the tobosa—grama association. The other specimen was taken in the catclaw—cedar association. This species may be restricted to the Plains belt.

Coluber flagellum testaceus Say. The coachwhip occurred more commonly in the Plains belt than in the Roughland belt. Of 10 specimens collected, only two were from the Roughland belt. One of these was in the stream bed association, and the other was in the lechuguilla—beargrass association on top of the mesa. Specimens from the Plains belt were from the following associations: catclaw—tobosa, four; creosote—

bush—catclaw—blackbrush, one; mesquite—huisache—blackbrush, one; and yucca—tobosa (near the center of the plain on the road from Valentine to Marfa), one. Several others were seen on the highway but they escaped into the rocky banks of drainage culverts. Two of our specimens have a distinct reddish color anteriorly and ventrally while another is dark red. These three red specimens also show a darkening of the dorsal head scales and each dorsal scale on the body is black tipped. The other specimens show the more typical yellow-tan dorsal color. One specimen was seen with its head and neck protruding from a rodent burrow beneath a catclaw bush. As we approached, the snake retreated down the burrow and our attempts to find it by digging were fruitless. Two additional specimens were collected in 1947 by Bair, Miller, and Walker from the Miller ranch, but the associations were not recorded.

Coluber taeniatus ornatus (Baird & Girard). This form is called **Coluber taeniatus girardi** Stejneger & Barbour by those who suppress secondary homonyms. Seven specimens collected on the Miller ranch are from the following associations of the Roughland belt: catclaw—grama, one; stream bed, six. One specimen was found dead on the road 15 miles north of Porvenir in the ocotillo—creosote-bush association of the Rio Grande Basin district.

Salvadora grahamiae Baird & Girard. Seven specimens were collected on the Miller ranch, all from rocky areas. One was taken in the catclaw—cedar association of the Plains belt. One escaped into a gopher burrow in the lechuguilla—beargrass association and another escaped into a rodent burrow in the catclaw—cedar association. The others were from the following associations of the Roughland belt: stream bed, two; catclaw—grama, two; grama—bluestem, one; lechuguilla—beargrass, one.

Salvadora hexalepis deserticola Schmidt. Unlike **S. grahamiae,** this species seemed to occur mainly in the Plains belt. Two specimens were taken, however, in the Roughland belt, where one each was caught in the stream bed and huisache—lechuguilla associations. The four specimens from the Plains belt were taken in the following associations: catclaw—tobosa, one; tobosa—grama, one; creosote-bush—catclaw—blackbrush, two.

Elaphe laeta intermontanus Woodbury & Woodbury. Two specimens, a male and a female, were collected five miles north of Porvenir in the salt cedar—mesquite association of the Rio Grande Basin district. They were active when found about 6 p.m. The male has a total length of 1054 mm. and a tail length of 189 mm. The ventral scale count is 207 and the subcaudal scale count is 72. There are 58 dorsal blotches on the body plus 19 on the tail. These blotches together with the black edge are about two and one-half scale lengths wide on the mid-dorsal line and are separated by bands of gray dorsal color about one scale wide; the blotches extend laterally over the median 11 or 12 scale rows. The female also has a total length of 1054 mm. and a tail length of 163 mm. The ventral scales number 222, and the subcaudals number 64. There are 48 dorsal blotches on the body plus 14 on the tail. Our specimens agree more closely with **E. l. intermontanus** Woodbury and Woodbury

(1942) than with **E. l. laeta.** They do not agree completely, however, with either form. Additional work is needed on this species in western Texas.

Elaphe subocularis (Brown). This species may be called **Elaphe sclerotica** Smith (1941) by those who suppress secondary homonyms. These snakes occurred in the Roughland belt of the Sierra Vieja district and in the rocky parts of the Plains belt adjacent to the mountains. All of our specimens were taken from the general vicinity of the mouth of ZH Canyon. Collections were made in the following rocky associations of the Plains belt: catclaw—tobosa, one; catclaw—cedar, four. In the Roughland belt specimens were taken in two associations as follows: catclaw—grama, six; and stream bed, one. We find previous records of the species from the type locality, 50 miles south of Pecos, Texas and from two localities in Coahuila, Mexico. In view of the scarcity of published records, it seems worthwhile to note some characters evident in our series of eight males and four females. Our series is described as follows: scalation; scale rows, 33-33-23 in eight specimens, 35-33-23, 33-35-23, 33-33-21, 31-31-23 in the other four; ventrals, 263-177, (mean 270.5); subcaudals, 71-79 (mean 74.0); supralabials 10 to 11; infralabials usually 14-14, but 15-15 in two specimens and 16-15 in one; loreals usually 2-2 but frequently reduced to one on one side or the other; preocular single; postoculars usually 2-2, but 3-3 in two specimens; suboculars 3-3 in five specimens, 2-2 in four, 2-3 in two and 3-2 in one. Other charaters are as follows: spots on body 21-24, on tail 8-9; total length 818-1443 mm. (mean 1106.7); tail length 119-180 mm. (mean 151.9); tail length/total length .125-.146 (mean .137). These characters as well as the coloration agree with Brown's (1901a) description of the type series from approximaely 50 miles, airline, north-north-east of the Miller ranch. Our series differs radically in scale rows (usually 33-33-23) from a specimen (scale rows 21-23-21) reported by Smith (1939) from near Saltillo, Mexico, about 450 miles south-east of the Miller ranch.

All of our specimens were taken between sunset and about 10 p.m. while they were apparently foraging; none was found with obvious food lumps in it. These snakes seemed to prefer rather calm nights, and surprisingly none was found on the several moist or rainy nights of the trip. The light from gasoline lanterns did not seem to disturb them, and they made little attempt to bite or escape when captured. One specimen was first located by the reflection of the rays of an electric headlight from its eyes. Walker (1938) lists five snakes which show reflection in the eyes only one of which is a North American form, **Agkistrodon mokasen**, the copperhead.

Pituophis catenifer sayi (Schlegel). Bullsnakes were found most commonly in the Plains belt, but a few were found in the Roughland belt. Four specimens were collected from the following associations of the Plains belt; catclaw—tobosa, two; creosote-bush—catclaw—black—brush one; tobosa—grama, one. One specimen from the Roughland belt was taken from the lechuguilla—beargrass association. A specimen was taken by Blair in the catclaw—grama association in April, 1948. Association data are not available for four other specimens taken by Miller in 1947 .

Lampropeltis alterna (Brown). One female specimen was collected near the mouth of Fox Hollow on the Miller ranch. It was active about 10 p.m. in the catclaw—grama association. According to Schmidt & Davis (1941) only five previous specimens have been reported. The specimen agrees in general with Brown's (1901b) description of the species but the variable characters seem worthy of description. Our specimen is described as follows: postoculars 2-2; temporals 3-3-4 on the left side and 2-3-4 on the right; supralabials 7-7, 3rd and 4th in the eye; infralabials 11-11; scale rows 25-25-21; ventrals 219; subcaudals 63; total length 542 mm.; tail length 88 mm. The dorsal color is gray. On the body there are 36 black transverse bands narrowly edged with white. Complete bands, two to three scales wide (mid-dorsally), alternate with a narrower band one to two scales wide. The narrow bands are broken dorsally, dorso-laterally, or both by the ground color. Of the wider bands, the three most anterior bands and the last one just anterior to the anus are split transversely by a rather definite red band. The remaining wide bands and a few of the narrowed ones have scattered red flecks on the black scales. Small black spots, mostly lateral, are irregularly scattered between the bands. The head is gray, irregularly mottled with black. A dark stripe passes from the eye to the angle of the mouth. Immediately behind the head, there is a red-centered black spot and other scattered black spots which probably represent broken bands. On the tail there are five wide bands which form rings around the tail. The first band posterior to the anus is split dorsally by a red band. The narrow bands are represented on the tail by round mid-dorsal spots. The ventral surface is dark gray with an indefinite midventral stripe of white. Along the lateral edges or the ventral plates there is a white stripe which is broken by the extension of the dorsal bands into the dark ventral color.

Lampropeltis getulus splendida (Baird & Girard). Two specimens were collected in the northeastern part of the Valentine plain. One was 3.2 miles west of Marfa, the other was 12 miles west of Marfa, both dead on the road. The surrounding association was yucca—tobosa. Another was seen dead on the road at Valentine but was not collected. The species was probably active at night and more common than these records indicate.

Rhinocheilus lecontei tesselatus Garman. Two males and one female were collected from the catclaw—grama association of the Roughland belt. One male was collected from the catclaw—tobosa association of the Plains belt. All were collected while active on clear nights. Klauber (1941a) gives 14.0% of the total length as the maximum tail length of females. Our one female has a tail length of 15.1%. The males are well within Klauber's ranges of variation for this subspecies. An interesting variation is found in the ventral markings of the four specimens. One male is cream colored ventrally, (Plains specimen) lacking any dark markings. Another male has definite dark blotches on almost every ventral scale. The other two are about midway between these extremes having dark blotches on every six to ten ventrals.

Sonora episcopa (Kennicot). One specimen was found in the catclaw—grama association of the Roughland belt. The specimen was dark gray in color, had no black bands and both loreals were missing.

Thamnophis eques cyrtopsis (Kennicott). This species was found very commonly around the pockets of water in the stream bed association of the Roughland belt. Of 102 specimens taken on the Miller ranch in 1948, all were from the stream bed association except for one from a lake in the tobosa—grama association and two from the catclaw—cedar association at the mouth of ZH Canyon. Most specimens were taken during the day. Many of them were found feeding on **Hyla arenicolor** larvae, which were common in pools. One specimen was found with the head and forelimbs of a large adult **Rana pipiens** protruding from its mouth. Four additional specimens taken in 1947 by Blair, Miller and Walker were all from the stream bed association.

Thamnophis marcianus (Baird & Girard). This species seems to be restricted to the vicinity of more or less permanent water in the Plains belt, but it may extend up the stream bed association into the Roughland belt. Of five specimens taken on the Miller ranch, two at a lake in the tobosa—grama association, and two at a tank in the catclaw—cedar association, four were active on nights of light rain. One, taken in late afternoon in the stream bed association at the mouth of ZH Canyon, regurgitated the hind quarters of a **Holbrookia maculata).** One specimen was taken early in the morning from the old field association of the Rio Grande district.

Hypsiglena ochrorhyncha texana Stejneger. This species seemed to be restricted to rocky areas. Five specimens were taken in the Roughland belt, while only one was caught in the Plains belt (catclaw—cedar association). Of the Roughland belt specimens, two were from the stream bed association, and three were from the catclaw—grama association. All were caught while active at night except for one which was found during the day under a rock. The Sierra Vieja region is intermediate between the ranges of **H. o. ochrorhynchus** and **H. o. texana** as limited by Tanner (1942). Our material is arbitrarily referred to the latter form.

Trimorphodon vilkinsonii Cope. A specimen was found active and apparently foraging at the junction of the stream beds of Fox Hollow and Box Canyon, about nine p.m., on a clear, calm night. The surrounding area was extremely rocky, a habitat of many other members of the genus.

Klauber's review (1941b) of the genus indicates the presence of only three other known specimens of this species. Klauber described the three specimens in detail. Cope (1886) described the type and Taylor (1939) described another.

Our specimen is 625 mm. long. There are 229 ventrals and 84 subcaudals. The scale row count is 21-22-17. The head scalation corresponds closely to that given by Klauber. The loreals are 3-3, the third being small and inferior to the posterior as in the type. The preoculars are 3-3, with the middle one smaller than the others. The postoculars are 3-3. The temporals are 3-4-5. The supralabials are 9-9, with the 4th and 5th contacting the eye; the 4th, 5th, and 6th are larger than the others. The infralabials are 12-12. The fifth is largest, and the first pair contact in the mid-ventral line.

The color pattern, with exceptions, matches that of Klauber's description. The head has three dark-brown spots on a grey background. One spot is on the posterior part of the frontal, and there is one on the anterior part of each parietal. The spots on the parietals are connected to the one on the frontal by light brown marks. There are 20 dark-brown body bands on a gray background. The first 11 spots are constricted at the median line. The area lateral to these constrictions is four to five scales wide in the first seven bands and three scales wide in the others. There are 12 tail bands, each two to three scales wide except for the most posterior one, which is one scale wide. Each back and tail band is bordered both posteriorly and anteriorly by a very light band, which is one scale wide. The lateral edges of the body bands are one scale wide. All but the last four bands reach the ventrals. All but the first four tail bands reach the subcaudals. These four and the last body band are two scales wide at the lateral edges. There are one to three lateral spots of dark brown between each of the body bands. Each lateral spot covers one to three scales, and several of them overlap into the ventral surface. This gives the ventral surface a rather broken-edged effect.

The interspaces are four to nine scales wide. This is a marked difference from the specimens examined and described by Klauber (1941b). Klauber describes the interspaces as eight to twelve scales wide and the bands as four to five scales wide. The bands in our specimen are three scales wide except for the first seven. Our specimen differs from the other known specimens in the number of tail spots or bands. In our specimen there are twelve spots while in the others there are seven to ten. Our specimen has 84 subcaudals as opposed to 77-79 in the other specimens. Additional material will be necessary for determining interrelationships in this species.

Tantilla atriceps (Gunther). One specimen was taken near the Miller ranch house in the tobosa—grama association.

Crotalus atrox Baird & Girard. The Western Diamondback rattlesnake seemed to be much less common in the area than we had expected. From other ecological records it seems that the species should occur throughout the area. We obtained only six specimens, four from the creosote—bush—catclaw—blackbrush association of the Plains belt and two from the salt cedar—mesquite association of the Rio Grande Basin district. One of the Rio Grande specimens was taken while active at night, and the other was found coiled in the shade of salt cedars about 8 A.M. The Miller ranch specimens were found either coiled in the shade of bushes or active in the late afternoon. One specimen was seen dead on the road 15 miles north of Porvenir in the ocotillo—creosote—bush association of the Rio Grande Basin district. The pinkish color noted by Gloyd (1940) in specimens from southeastern Arizona and southwestern New Mexico was present in all our specimens. The reddish color is increased posteriorly in the largest specimens and the pattern is more indistinct in these than in the smaller ones.

Crotalus l. lepidus Kennicott. Four specimens were collected from the following associations of the Roughland belt: catclaw—grama, two; stream bed, two. All were active when taken, two at night and two in the early morning. One of the catclaw—grama specimens was in a rock slide within the association.

Crotalus m. molossus Baird & Girard. Six specimens were collected. All came from the Roughland belt except one from a very rocky area in the catclaw—cedar association of Knox Canyon alluvial fan. Three were taken in the catclaw—grama association and two in the stream bed association. Two of the specimens from the catclaw—grama association and one sighted but not caught, were found in rock slides within the association. The sight record animal was located about 11 a.m. Removal of rocks in an attempt to catch the snake resulted in the discovery that the air between the rocks of the slide was very noticeably cooler than the surrounding air. Such rock slides probably furnish important cover during the hot days for crepuscular and nocturnal species in the area. Four specimens were caught at night and one each was caught in early morning and later afternoon giving strong evidence for the crepuscular and nocturnal habits of this species.

Crotalus s. scutulatus (Kennicott). One specimen was collected by Blair in July, 1947 from an old gopher burrow in the tobosa—grama association of the Plains belt.

Crotalus v. viridis Rafinesque. One specimen was taken by Miller in June, 1947, from the tobosa—grama association of the Plains belt. A single specimen was seen by our party about 10 miles north of the Miller house in the tobosa—grama association. This animal was coiled in the mouth of a prairie dog (**Cynomys ludovicianus**) hole, and it escaped down the burrow when molested.

BIOGEOGRAPHIC RELATIONSHIPS

The amphibians and reptiles collected in the Sierra Vieja region represent several major faunal elements. The relations of these elements are as follows, and the forms that are restricted in the region studied to the Roughland life belt (**) and the Plains life belt (*) of the Sierra Vieja biotic district and to the Rio Grande biotic district (***), are indicated:

Five species are widely distributed in North America and occur in several biotic provinces. These widely distributed species include:

Ambystoma tigrinum*
Rana pipiens**
Sceloporus undulatus*
Lampropeltis getulus*
Coluber flagellum*

Eighteen species are widely distributed in western North America and occur there in several biotic provinces. This western faunal element includes:

Scaphiopus hammondii*
Bufo compactilis***
Bufo cognatus***
Holbrookia maculata*
Crotaphytus collaris**
Usosaurus ornatus**
Uta stansburiana***
Cnemidophorus gularis**
Cnemidophorus tessellatus***
Heterodon nasicus*
Coluber taeniatus**
Elaphe laeta***
Pituophis catenifer
Rhinocheilus lecontei**
Thamnophis marcianus*
Hypsiglena ochrorhyncha**
Crotalus atrox*
Crotalus viridis*

Eight species have ranges which center in the Great Plains of the central United States. The plains species include:

Bufo insidior*
Microhyla olivacea
Phrynosoma cornutum*
Eumeces obsoluetus**
Terrapene oranta*
Kinosternon flavescens*
Sonora episcopa
Tantilla atriceps*

Twelve species have their centers of distribution in Mexico and range into the Sierra Vieja region from the south. These include:

Scaphiopus couchii*
Bufo punctatus**
Hyla arenicolor**
Holbrookia texana**
Eumeces brevilineatus**
Leptotyphlops humillis**
Diadophis regalis**
Salvadora hexalepis
Thamnophis eques**
Crotalus scutulatus*
Cotalus lepidus**
Crotalus molossus**

Ten species appear to be largely limited to the Chihuahuan biotic province. These are:

Syrrhophus gaigae**
Cnemidophorus grahamii**
Cnemidophorus perplexus*
Coleonyx brevis**
Phrynosoma modestum*
Sceloporus poinsettii**
Salvadora grahamiae**
Elaphe subocularis**
Lampropeltis alterna**
Trimorphodon vilkinsonii**

The forms indicated here as Roughland life belt (**) refer to those apparently restricted by the rocks in the area.

The proportions of the several faunal elements in the Sierra Vieja region are as follows: 10 species (19.0%) largely restricted to the Chihuahuan province; 18 species (34.0%) widely distributed in western North America; eight species (15.1%) Great Plains; 12 species (22.5%) Mexican; and five species (9.4%) widely distributed in North America.

A comparison of the herpetological fauna of the Sierra Vieja region as known from our material with that of the Big Bend region as described by Strecker (1909) and by Schmidt and Smith (1944) shows a considerable difference between the regions. Thirteen species recorded by us from the Sierra Vieja region were not listed previously from the Big Bend region. These include:

Ambystoma tigrinum
Scaphiopus couchii
Scaphiopus hammondii
Bufo cognatus
Bufo compactilis
Microhyla olivacea
Holbrookia maculata
Heterodon nasicus
Lampropeltis alterna
Lampropeltis getulus
Sonora episcopa
Trimorphodon vilkinsonii
Crotalus viridis

Seventeen species which have been recorded from the Big Bend area were not obtained by us in the Sierra Vieja region. These include:

Acris crepitans
Bufo woodhousii
Pseudemys floridana
Pseudemys scripta
Platypeltis emoryi
Sceloporus magister
Sceloporus merriami
Gamelia wislizenii
Gerrhonotus liocephalus
Ficimia cana

Leptotyphlops dulcis
Sonora semiannulata
Elaphe bairdi
Arizona elegans
Natrix erythrogaster
Natrix rhombifera
Agkistrodon mokasen

A complete review of the faunal relations of the various biotic districts of Trans-Pecos Texas is here impossible due to the lack of knowledge of these little known regions. Some deductions can be made, however, from the rather notable differences in the herpetofauna of the Sierra Vieja and Big Bend regions.

Thirteen forms were found in the Sierra Vieja region but not in the Big Bend. Difference in field technique will probably explain the absence of **Ambystoma tigrinum** from the Big Bend list. These salamanders were extremely common in the ponds and lakes of the Plains life belt of the Sierra Vieja district. Several anurans (**Scaphiopus couchii, Scaphiopus hammondii, Bufo cognatus, Bufo compactilis, Microhyla olivacea**), common in the Sierra Vieja region, are probably present in the Big Bend. Lack of records from that area may possibly be explained by the short breeding season and the limitation of movements of these forms to this period. We are surprised that **Holbrookia maculata** is not recorded from the Big Bend region for it is a common form in the Sierra Vieja biotic district and has a general range extending far to the east of our region into central Texas. Two snakes, **Lampropeltis alterna** and **Trimorphodon vilkinsonii,** are rare forms. The known range of the latter lies considerably west of the Big Bend, but the records of the former encircle that region. Three snakes, **Heterodon nasicus, Crotalus viridis,** and **Sonora episcopa** are scarce forms which would possibly be recorded in the Big Bend region by further search. It is strange that the Big Bend list does not include records for **Lampropeltis getulus,** and that this species was so scarce in our records.

Of the seventeen forms recorded in the Big Bend region but not in the Sierra Vieja region, **Pseudemys floridana, Pseudemys scripta, Platypeltis emoryi, Sceloporus magister, Gambelia wislizenii, Natrix erythrogaster,** and **Natrix rhombifera,** are possibly present in the Rio Basin biotic district of our region. Several species (**Acris crepitans, Sceloporus merriami, Sonora semiannulata, Agkistrodon mokasen,** and **Gerrhonotus liocephalus**) reach their known western limits in the Big Bend region and may not extend into the Sierra Vieja region. Three snakes (**Arizona elegans, Ficimia cana, Elaphe bairdi**) are rare forms which possibly occur in the Sierra Vieja region although we were unable to obtain records. We are surprised that we were unable to obtain **Bufo woodhousii** and **Leptotyphlops dulcis** for they are apparently common in the Big Bend and other surrounding regions.

Strecker (1909) records **Eumeces tetragrammus** from the Big Bend region but this record is far from the western limits of the species as described by Smith (1946) and is not confirmed by subsequent workers in the Big Bend region.

SUMMARY

The ecological distribution of the reptiles and amphibians in the Sierra Vieja region of Trans-Pecos Texas was studied from June 3 to July 9, 1948.

Fifty-three species of reptiles and amphibians were recorded from the area. These included ten species of anurans, one species of urodele, two species of turtles, 16 species of lizards and 24 species of snakes.

In the Sierra Vieja biotic district 26 species were apparently limited to the roughlands or to an intermediate zone of more or less rocky alluvial fans adjacent to the canyon mouths. Eleven of these did not extend down even into the intermediate zone. Nineteen species were limited to the association of the Plains belt. Six of these were apparently limited to the sandy areas of the plains. Three species ranged through both life belts. Five species were found only in the Rio Grande Basin biotic district.

Of the 53 species recorded, 10 (five lizards, four snakes, one frog), 19.0 per cent of the fauna, were largely limited to the Chihuahuan biotic province. Twelve (22.5%) of the species have their centers of distribution in Mexico, and eight (15.1%) are Great Plains in their affinities. The other forms (43.4%, 23 species) are wide ranging either in western North America or over much of the continent.

Thirteen (24.5%) of the species recorded in the Sierra Vieja region have not been found in the Big Bend region. Seventeen (30.4%) of the species recorded in the Big Bend region have not been found in the Sierra Vieja region.

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TABLE I

Numbers of specimens of reptiles and amphibians collected in each ecological association of the Plains Life Belt of the Sierra Vieja Biotic District.

SPECIES RECORDED	RECORDS IN ECOLOGICAL ASSOCIATIONS							
	Yucca—Tobosa	Blackbrush—Creosote-bush	Yucca—Blackbrush—Grama	Catclaw—Tobosa	Tobosa—Grama	Mesquite—Huisache—Blackbrush	Creosote-bush—Catclaw—Blackbrush	Catclaw—Cedar
Plains Belt Species								
Scaphiopus couchii		1					1	2
Scaphiopus hammondii					12			
Bufo isidior					179			
Ambystoma tigrinum					171			
Kinosternon flavescens					12			
Terrapene ornata	3	2		4	3		3	1
Holbrookia maculata				38	14	7	1	1
Sceloporus undulatus				3	1		1	6
Phrynosoma cornutum		5	2	30	5	14	2	2
Phrynosoma modestum		1		9		1		3
Cnemidophorus perplexus		8	2	174	1	2	3	53
Heterodon nasicus					1			1
Coluber flagellum	1			4		1	1	
Lampropeltis getulus	2							
Thamnophis marcianus					2			2
Tantilla atriceps					1			
Crotalus atrox							4	
Crotalus scutulatus					1			
Crotalus viridis					1			
Wide Ranging Species								
Microhyla olivacea					9			3
Salvadora hexalepis				1	1		2	
Pituophis catenifer				2	1		1	
Roughland Belt Species								
Bufo punctatus				2	3		3	30
Rana pipiens					1			15
Coleonyx brevis								21
Crotaphytus collaris				1			1	6
Holbrookia texana				1			2	30
Sceloporus poinsetti								2
Urosaurus ornatus								9
Cnemidophorus grahamii							14	4
Cnemidophorus gularis				3	2	3		29
Eumeces obsoletus								1
Salvadora grahamiae								1
Elaphe subocularis				1				4
Rhinocheilus lecontei				1				
Thamnophis eques					1			2
Hypsiglena ochrorhyncha								1
Crotalus molossus								1

TABLE II

Numbers of Specimens of Reptiles and Amphibians collected in each ecological Association of the Roughland Life Belt of the Sierra Vieja Biotic District. The symbol x indicates sight or call records where actual specimens were not collected.

SPECIES RECORDED	RECORDS IN ECOLOGICAL ASSOCIATIONS					
	Stream bed	Catclaw—Grama	Grama Bluestem	Rock bluff	Lechuguilla—Beargrass	Huisache—Lechuguilla
Roughland Belt Species						
Bufo punctatus	4	6				
Hyla arenicolor	13					
Syrrhophus gaigeae	x	x		x		
Rana pipiens	14					
Coleonyx brevis	7	8			1	
Crotaphytus collaris	1	2			3	
Holbrookia texana	8	10				
Sceloporus poinsetti	9	6		2		
Urosaurus ornatus	74	34		8	7	
Cnemidophorus grahamii		10	2		1	
Cnemidophorus gularis	42	47	2		36	
Eumeces brevilineatus	5	2				
Eumeces obsoletus	x	3				
Leptotyphlops humilis	1	1				
Diadophis regalis	2					
Coluber taeniatus	6	1				
Salvadora grahamiae	2	2	1		1	
Elaphe subocularis	1	6				
Lampropeltis alterna		1				
Rhinocheilus lecontei		3				
Sonora episcopa		1				
Thamnophis eques	103					
Hypsiglena ochrorhyncha	2	3				
Trimorphodon vilkinsonii	1					
Crotalus lepidus	2	2				
Crotalus molossus	2	3				
Wide Ranging Species						
Microhyla olivacea	8	2				
Salvadora hexalepsis	1					1
Pituophis catenifer		1			1	
Plains Belt Species						
Scaphiopus hammondii	2	1				
Sceloporus undulatus		1				
Phrynosoma modestum		1				
Coluber flagellum	1				1	
Thamnophis marcianus	1					

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TABLE III

Number of Specimens of Reptiles and Amphibians collected in each Ecological Association of the Rio Grande Basin Biotic District. The symbol x indicates sight or call records where actual specimens were not collected.

SPECIES RECORDED	RECORDS IN ECOLOGICAL ASSOCIATIONS				
	Ocotillo Creosote-bush	Catclaw Creosote-bush	Salt Cedar Mesquite	Oil Field	Cottonwood
Scaphiopus couchii		x	1		
Scaphiopus hammondii			7		
Bufo cognatus			1		
Bufo compactilis		1	24		
Holbrookia texana		2			
Sceloporus undulatus					1
Uta stansburiana		3			
Urosaurus ornatus			1		
Phrynosoma modestum	1	1			
Cnemidophorus grahamii		6	3		
Cnemidophorus testallatus	1	49	2		
Coluber taeniatus	1				
Elaphe laeta			2		
Thamnophis marcianus				1	
Crotalus atrox	x		2		

HOW SOCIAL SCIENCES MAY MEET THE CHALLENGE OF TODAY

FRANK E. LUKSA
Southwestern University

Mankind is living in a period of momentous change, in a transitional period which, in an octopus-like fashion, reaches and affects the world in all inhabited regions. The present crisis cuts a diagonal through all social institutions regardless of their level of cultural development. The upheaval recognizes no geographic barriers, races, nations, political ideologies, or economic systems.

The present decade, no doubt, will be recorded by future historians as the beginning of a fourth major period in the history of man's cultural development. Each of the three periods designated by historians as ancient, medieval, and modern has been ushered in by fundamental changes in social institutions and patterns of life somewhat comparable to the changes which we are experiencing today.

In the words of Oswaldo Aranha, new president of the United nations, "The people that disintegrated the atom now have the mission of integrating humanity," we find that we as a nation have the privilege of taking part in one of the greatest missions mankind has ever set out upon. The present crisis is a call to mental arms for men and women of good will everywhere and in the United States in particular. The world has a choice of either moving forward together into a truly enlightened era or suffering the fate of Hiroshima. Our present day is charged with powerful opposing forces, with conflicting issues, and contradicting ideologies. The way in which these almost insurmountable problems will be solved today or within the next few months will have a far-reaching effect upon the future of mankind. There is enough enlightenment and good will among men today to solve the problems to the best advantage of the future generations. However, there is a possibility that through sheer recklessness, inefficient maneuvering, and subterfuge, the same men can lead this world to destruction.

I cannot admit that man is unable to extricate himself from the maze of present swift-moving events and that he is doomed to certain and unavoidable destruction along with his total culture heritage. An attitude of resignation on the part of any of us would seem to indicate unawareness of the fact that the present day crisis is nothing more than another movement in the development of man's history. Some observers may say that there is no parallel in history to the intricacy and seriousness of present day problems. To give up and live in fear, awaiting the fatal day when some nation, by a push-button arangement, will set in motion the destructive forces would be folly. Such an attitude would be comparable to a man who finds himself in a swift current and refuses to pick up the oars in the bottom of his boat to save himself from the inevitable plunge over the falls.

During the last one hundred years natural science has wrought tremendous changes. It has extended man's control over nature. It has enabled him to produce material goods faster and in greater quantities than anyone dared dream only a generation ago. Distance has been obliterated and men bound together into a shrunken world. Diseases, famines, epidemics, and plagues have been almost eradicated. This list could be extended indefinitely. All in all man enjoys comfort and ease, especially in our country, whether he reads the daily paper by his fireside or goes by the fastest plane to an executive meeting of his big corporation. No one who has lived and experienced the advantages of science would care to exchange today for yesterday.

In spite of all the above mentioned, and many other desirable changes natural science has brought us, it failed to bring us knowledge of values which ultimately must form the broad foundation upon which the future world must rest. The growth and rapid expansion of science have not been accompanied by the necessary growth of wisdom. The changes which have bound us together mechanically have not taught us to live together socially, politically, or economically. The world we have created has within it too much self-centered indifference, excessive hate, needless brutality, miscarried justice, and disregard for all the finer qualities and rights justly belonging to every human being created in the image of God.

The writer does not mean to imply that natural sciences should take a vacation and give the social sciences time to make proper implementations in the area of human relations. He does not minimize or underestimate the valuable contributions made by natural sciences, but wishes to point out the gap between what natural sciences have contributed and the knowledge to use these contributions in the best interest of society. Atomic power per se is impotent. How man uses it and integrates it into the total culture pattern is what makes the difference that counts. Let the natural sciences continue in their research, to stop them is impossible within our democratic government. However, the natural scientist and the social scientist must cooperate and coordinate their work in the future, otherwise the truths discovered in both areas may ultimately be destroyed. The explosion at Hiroshima was only a sample of what may come later and also a revelation of the truth that the natural scientist is too far ahead and the social scientist lagging behind with excess baggage which he has refused to discard or convert into beneficial uses.

WHAT MAY THE SOCIAL SCIENCES DO?

It is not in the scope of this paper to present a plan for each social science and show what its particular responsibility should be in meeting the challenge of today. It is a well known fact that the social sciences overlap in the areas which they study, that they are closely related and interdependent. What can be said of one in connection with the present day challenge may be applied to others. Taking the total area in which social sciences are working, let me make the following suggestions as to how our present crisis may be met.

Human relations have been a subject for scientific study for quite some time. Social scientists have accumulated vast resources of knowledge and have developed and refined methods and procedures. They have compiled statistics and voluminous data on various phases of human behavior and misbehavior and have arrived at conclusions that are valid. Why then, are we still confronted with so many social problems, locally, nationally, and internationally? The trouble is not in the lack of knowledge of human problems, but in the lack of better and more rapid application of what we do know. Are we applying to the fullest extent that which we know? After all, any scientific law in any science has practical utility and value only to the extent that it is applied to the solution of social problems or in some way used for the advancement and improvement of the social order. I am convinced that we can find enough evidence to show that we are not applying all we know. In the area of family relations enough research has been carried out to throw light on what is necessary, proper, and desirable in all the relations between future mates prior and after marriage. Yet in spite of all this knowledge, divorce rates are steadily mounting. Juvenile delinquency is still on the increase. We also know a great deal about reforming and rehabilitating those whom we legally term criminals; yet the present set-up in most of our penal systems is obsolete and not conducive to rehabilitation and reformation of the inmates. We still send teen-agers to reformatories which are anything but places of reformation. If we turn our attention to the treatment of our racial minorities, again we are guilty of not applying what we know is just, honorable, and human. In better and more adequate education we are lagging even though we know it is the best cure for intolerance and bigotry, hatred, and suspicion. Only better education will pay greater dividends in terms of improved human relations. On the international scene we have also failed. We fear Communism, Fascism, and other "isms." We are sending material aid to European countries threatened by Communism. I am not against material aid, but I cannot admit that we can sell those people our way of life and instill in them principles of democracy by sending over shiploads of potatoes, shoes, rice, or other material items. Communism cannot be stopped and democracy effectuated by a "mess of pottage" anywhere at any time. Fundamental principles conducive to happiness and future world peace cannot be transported in wooden boxes or parcels of any kind. We should have learned that lesson twenty-five years ago. These principles must be first in the hearts of men; they must be lived by and practiced and if need be, paid for by the supreme sacrifice. We know we have failed to make democracy appealing enough to all our own people. We need to clean our own house before we attempt to sell others our way of life. Let me borrow an illustration from one of our leading political figures of today. He illustrates the above point by saying that a merchant cannot stay in competition long if he criticizes the goods and services of other merchants. In order to stay in business he must sell goods of equal or better quality.

Democracy must be made more attractive and desirable to all of our own people and then it will sell itself. The eyes of the world are turned to our country for leadership. Shall we as social scientists pass up the opportunity to do our share with what we know and have at our disposal? The only limitations on fulfilling the above suggestion of applying more speedily what we know are limitations that we impose ourselves.

Natural sciences have brought the world together; social sciences must teach the world how to live together. This is my second suggestion for our consideration today. The explosion of the atomic bomb suddenly made the world feel welded together through some mysterious bond. In the past, whenever a revolutionary invention or discovery was made, it was allowed to take time to find its place in the fabric of society. Naturally there were maladjustments on the part of individuals and groups as they were readjusting their lives to the new culture trait by the trial-and-error method. The age of speed in which we are living today does not allow the use of such a method.

To prevent man's doom and complete disintegration, we must speed up learning how to live together as individuals and nations. We have the "know how," let us apply it. For centuries man has dreamed of a world bound together by human love, which is not self-centered, egotistic, and proud. For centuries man has dreamed of a world filled with truth, goodness, and beauty. It is the duty and obligation of social sciences to promote the building of such a world and help man's dream to become a reality. Social scientists must promote contacts between intellectual workers, leaders of groups, and the masses of people everywhere. One of their specific objectives must be to further the cause of the world peace through the diffusion of knowledge and the promotion of understanding. The new power of destruction created by man is powerful, but it stands impotent against the forces of mutual understanding, cooperation, and appreciation. These forces cannot be tested at Bikini Island, but must be tested and implemented into every human heart wherever it beats. The truths discovered by social scientists must be put to use on the unbeaten paths of humanity. Through common action and thought they must direct the world into a creative community. The intellectual and spiritual potentialities of mankind are still great. Every person regardless of his depravity and wickedness or degree of cultural advancement, feels at times that he wants to do better, to help someone, to show appreciation, cooperation, and respect to his fellow man. There is still enough goodness left in humanity to make this world a better place in which to live. There are many fine qualities in man which have not yet been fully exploited and are begging for intelligent guidance and leadership. During the last war many of the European countries have seen their cultural resources destroyed; ours remained intact. The cultural reconstruction of Europe calls for something more than material aid. A world-wide conscience must be built in the people of Europe after it has been developed in our country. They must be made to feel they are an integral part of the total world community and not only necessary appendages to this or that leading power. They must be made to feel that they count beyond the immediate boundaries of their respective communities. World interests must be their interests; their interests must be part and parcel of the world. A peace based on selfish political and economic arrangements cannot be permanent, and it cannot secure the backing and endorsement of all the peoples of the world. A broken world cannot be made whole by policies of hate and by policies dictated by the desire of individual or national advantage. In order for world peace to be secure, it must be built on principles leading to the preservation of dignity and worth of the human person. It must be a peace in which human rights everywhere are protected. Social sciences must find it in their province to build a world where life for every individual will be meaningful. They must build a world where the specifically human qualities of goodness, friendliness, respect, and appreciation will find their maximum expression and growth unhampered by fear, distrust, injustice, and intolerance. Social scientists are those today who unquestionally are called to give leadership in the cause of peace. They have the necessary knowledge, education, and an insight into the world situation. If present social scientists with their social science cannot work toward such peace, then in the words of Dr. Louis Wirth, University of Chicago, "We must create a better social science that will be able to do so."

Finally, I do not wish to leave the impression that social sciences alone can save the world. Their work must be clearly integrated with natural sciences as well as with the humanities. The humanities delve into the creative powers of the human mind; their objective is to help man to understand himself and his relation to the universe. Together, they help the individual create for himself a fund of values which in turn either help or retard the solution of society's problems. To natural sciences we look for physical comforts, to social sciences for improvement of human relations, to the humanities for salvation of the human spirit.

SANDS OF THE TEXAS GULF COAST—A REVIEW

W. C. RASMUSSEN
Assoc. Professor of Geology
A. & M. College of Texas

Sands form the most important class of rocks known to man. The sand rocks have a greater variety of uses, and yield minerals of greater total economic value than do igneous or metamorphic rocks, or than all other sedimentary rocks, shale, limestone and coal.

It is the purpose of this review to consider the distribution of sand rocks in the Gulf Coastal Plain of Texas, the information available on these rocks, the present uses of sand in the rapidly industrializing area, future uses, and finally, to propose future research on the sand rocks. In order to understand the application of sand rocks, a first consideration is given to the composition of sand, the physical properties of sand rocks, the environment in which sand rocks accumulate, and post-depositional changes.

Sand may be defined as a rock composed of granular particles in the size range between gravel and silt. Most American geologists accept the limits 2mm. to 1/16mm. for this size range.[1] This definition includes both fragmental particles, derived from pre-existing rock, and shell fragments, fragments of volcanic ash, and non-fragmental particles, such as oölitic concretions, and firn ice (névé) [2] Of course, the term "sand" has special meaning to the doctor of medicine, who finds concretionary particles of sand size which form in certain organs of the body, or to the

1 Originally proposed by Udden (1898), and popularized by Wentworth (1922). Limits accepted by European geologists, by soil scientists and others are discussed in Chapter 4 of Krumbein and Pettijohn (1938).,

2 This is the broad interpretation held by Scherzer (1910), and modified on page 288 of Grabau (1932). Twenhofel (1939), page 281, excludes shell fragments, oolites and volcanic ash from his definition of sand.

manufacturer of maple syrup, who calls an insoluble precipitate of calcium malate, which forms in the syrup, a "sand", but these do not concern us here (Smith, 1946).

Sand is an unconsolidated material. However, sands are cemented together to form sandstone. There is progressive hardening of the rock from the loose sand to friable, loosely cemented, moderately cemented, well cemented sand, and, ultimately to quartzite, a quartz sand so firmly bound with siliceous cement that, upon breaking, the rock fractures across the grains rather than around them. Most quartzites have been formed by metamorphic processes involving abnormal heat and pressure, but they are known also among unmetamorphosed sediments, for example the Dunlap Quarry quartzite, of the Catahoula formation, of Brazos County, Texas.

The composition of most sand is quartz, although it is seldom pure, and may contain characterizing accessories of feldspar, mica, calcite, or glauconite. In addition, most sands contain, as minor accessories, about one percent, or less, of minerals of high specific gravity (greater than 2.8), which are termed the "heavy minerals." These can be separated from the mass of lighter minerals by settling in a heavy liquid, such as bromoform (specific gravity about 2.85). Early workers[3] found a typical heavy mineral suite in sands of the Texas Gulf Coast of leucoxene, ilmenite, magnetite, tourmaline, zircon, kyanite, staurolite, rutile, garnet, epidote, serpentine, olivine, actinolite, andalusite and sillimanite. This assemblage emphasizes metamorphic source rocks.

In the early 1930's, there was some hope that heavy minerals could be used for correlation, and therefore for structural determination, in the Gulf Coast. Then Cogen (1940) of Shell laboratories, considering over 2,000 heavy mineral samples, worked out five sub-surface zones in the Cenozoic: the lower Epidote, Staurolite, Kyanite, higher Epidote and Hornblende. Although these could be plotted on logs, and determined in outcrop traverse, they were found to transect formations and paleontologic horizons. "For example, the base of the Kyanite zone is shown to transgress from Eocene strata in the interior into Miocene post-Discorbis zone sediments near the coast."

These heavy mineral facies could thus not be relied upon for correlation, except possibly over a small area. Even then, heavy mineral work is so laborious that it cannot compete with electric logs and microfossils in correlation here in the Gulf Coast.

Almost every mineral known can be found in sands. Workable gold deposits are found in placer sands of mountain streams. "Stream tin", cassiterite, occurs locally as a heavy sand concentrate. Small diamonds are found in sand deposits, in fact the placer occurrences of India and Brazil were once the chief world source. Ruby, sapphire, emerald and other gems have been found in sands.

Where other constituents than quartz form all or an appreciable part of a sand, special rock names are employed. If the sand contains 25 percent or more of feldspar, the name arkose is used. If glauconite is abundant, the rock is called a greensand. If magnetite and ilmenite predominate, the rock is blacksand. If there is a predominance of dark

3 Lonsdale, Metz and Halbouty (1931); Woods (1934), page 48; Wendler (1934), page 94.

ferromagnesian silicates, the sand is a greywacke. If the sand grains are composed of calcite, the rock is a granular limestone. In southeastern New Mexico, there are brilliant white sands of gypsum. On the Hawaiian Islands are black sands of basaltic rock. On the shores of coral reefs are coralline sands. Parts of the Greenland ice cap and glaciers elsewhere are covered with sands composed of ice.

Few fossils are found in sands. This is partly because sand bottoms are a poor environment of life, a poor biocoenose, due to the sub-aqueous "sandstorms" of shifting currents. Nevertheless, a few crabs, sand dollars, sand hoppers, sand fleas, pelecypods and gastropods may be found. Scavengers and microbes destroy much of the organic material which does form. Dune sands likewise are poor environments of life, due to their shiftiness. Desert sands are formed under unfavorable temperature extremes and aridity. Deserts are environments of death, thanatocoenose, for vertebrates, whose bleached bones are preserved by a covering of sand, and by the low humidity. Dinosaur eggs from the Gobi desert and dinosaur bones in sands from there and elsewhere, attest to a preservation of at least 60 million years. Petrified wood fragments are common in some sands and sandstones, which represent neither the environments of life, nor death of the plant, but the environment of deposition. Shell fragments may be found in recent sands, but are rare in later deposits because the high permeability of sands permits leaching by moving ground waters. In general, however, sand rocks are unfossiliferous, because they are poor environments of life, of death, and of preservation.

The cements that fill the voids and bind the grains of a sand may constitute up to 35 percent by weight of a sandstone, although cement usually constitutes only between 10 and 20 percent of a moderately indurated stone. The most common cementing materials are the iron oxides and hydrates, calcium carbonate, silica and hydrous aluminum silicates: these are in the mineral forms of hematite, limonite, calcite, quartz and opal, and clay minerals, respectively, in most cases. The clay binder is probably contemporaneous in deposition with the sand, or syngenetic. The other cements may be almost contemporaneous, diagenetic, or introduced by ground waters long after deposition, epigenetic. The study of cementation of sands is becoming of increasing interest to the oil industry, since reservoir porosity is reduced by cementation, cementation generally increases with depth and with geologic age, and reservoirs are being sought at greater depth and greater geologic age throughout the world, but particularly in the Gulf Coast, where several wells have been drilled to depths in excess of three miles.

Concretions are not uncommon as a minor component of sandstones. Concretions are bodies which have grown in place, through successive deposition of salts carried by waters moving through the bed, upon some nucleus. Most concretions are ferruginous, many calcareous, and a few siliceous, for the same minerals that cement sands are deposited as concretions, enclosing grains of the bedded rock. The iron sulfides, pyrite and marcasite, also form concretions in sand, and barite and phosphatic nodules are known. Concretions vary in size from barely discernable to cannon-balls, and even tuberose ledges several hundred feet long. Usually they are a few inches across, with a shape varying from cylindrical to spheroidal, ellipsoidal, rosette, discoidal, to highly irregular. The original nucleus of deposition is seldom found, although the supposition is that it was a decaying piece of organic matter that set up redox potentials in concentric zones. Crabs have been identified as the nuclei of some concretions (Burt, 1932), and fossil leaf imprints have been found at the center of others. Concretions are usually harder and better cemented than the enclosing rock, and so they weather out and stand out in surface outcrops. They have been used for local tracing of beds, and mapping of structures in the shallow Gulf Coastal plain of Texas. They represent a local reduction of porosity, and sometimes a "boulder bed" of hard drilling in wells down dip in the coastal plain.

The colors and lusters of sands and sandstones are definitely related to the mineral grains, their alteration products and their cement. Quartz is usually colorless; feldspar white or pink; mica "salt and pepper," or pearly spangles; calcite white; glauconite green; magnetite and ilmenite black; ferromagnesian minerals, green, brown or black. The cement and alteration products are usually yellow, orange, or red-brown, due to the iron hydrates. The consequence is that most sandstones are white, buff, or brown; a few are green, grey, or black. Their luster is usually vitreous, although it may spangle with small flakes of mica, or be dull or earthy due to limonite or clay.

The texture of sand includes the size, shape, roundness, arrangement and surface properties of the grains. There are a wide variety of textures, which are clues to the last agent of transport and to the medium of deposition.

For example, the range of sand sizes, on the Wentworth-Udden grade scale, is sub-divided:

2 mm — 1 mm	Very coarse sand
1 mm — ½ mm	Coarse sand
½ mm — ¼ mm	Medium sand
¼ mm — ⅛ mm	Fine sand
⅛ mm — $\frac{1}{16}$ mm	Very fine sand

A sand may be sieved and the percentage of each fraction obtained. These percentages may be shown graphically in histograms, or in the modern cumulative frequency curve. From the graph, the average grain size may be determined; the spread around this average size, a measure of natural sorting of the sediment, may be calculated; finally any lack of symmetry, or skewness, of the curve, representing the tendency of more grains to cluster close to the average on either the finer or the coarser side, may also be determined.

The average grain size of a sand may characterize it locally. For example, the Carrizo sand in Frio and Atascosa Counties is reported to be medium grained by Lonsdale, Metz and Halbouty.[4] Since five other Eocene sand formations proved to be fine or very fine grained; these men thought this texture might be of general correlative value, downdip or along the strike. This did not prove to be so, however, for Woods[5] found the Carrizo sand in Wilson and Bastrop counties to be fine grained,

4 Lonsdale, Metz and Halbouty (1931). The writer drew cumulative curves of their eight sieve analyses and found the average median to be 0.40 mm with a median range from 0.59 mm to 0.25 mm, clearly a medium grained sand.

5 Woods (1934), p. 39.

on the basis of 30 analyses. In accord with previous analyses, though, he notes "an increase in coarseness of texture to the southwest." Trowbridge (1932) describes a medium-grained quartzite from the Carrizo along the Nueces River, in Vavala county, and presents five sieve analyses of the Carrizo from Webb county near the Rio Grande, of which two have the maximum grade as medium grained sand, two fine grained sand and one very fine grained sand.

Thus it is apparent that grain size alone is too variable to be of long range use. However, it is of local value, in differentiating and correlating a sand, and of general value for historical interpretation.

The spread of the grain size distribution, or "sorting," is an indication of the last agent that acted upon the sand. Dune deposits are highly sorted, open bay sands are well sorted, beach sands are highly sorted, delta sands are moderately sorted, river sands are poorly sorted, glacial kame, esker and ice deposits are crudely sorted or unsorted. Several simple formulae have been used to express sorting and as yet little standardization has been attained.[6] Sorting does tell something about the environment, but it is apparently not of correlative value.

The skewness, or asymmetry, of grain size distribution is a new parameter of relatively untested value, yet it appears that it has environmental significance.

Although the size, spread and skewness of a single sample may not be significant, the same parameters on a group of samples may form the pattern of sediment environment, or may give a pattern of correlative value, as demonstrated by Krumbein in Barataria Bay, Louisiana.[7]

The shape of sand grains has long been suspected of being of genetic or correlative value, but techniques have not yet been developed to allow general application of shape study to sands. For example, it has been stated[8] and denied (Anderson, 1926) that wind can round sand grains of smaller size than water, because water cushions impact. Twenhofel says: "It is generally believed that, if particles are rounded below dimensions of 0.1 mm., and the quantity is large, the rounding was done by aeolian agencies."[9]

Many techniques have been developed by Sorby, Wentworth, Trowbridge and Mortimore, Lamar, Pentland, Cox, Tickell, Tester, Hagerman, Fisher, Szadeczky-Kardoss and others,[10] most of which, for sands, involve making a projection of the individual grains, and measuring areas, angles, or circumscribing circles, all tedious processes. Unfortunately, most of the methods do not differentiate between shape and roundness, as pointed out by Wadell (1932, 1933, 1935).

Shape has to do with the form of a grain, whether discoidal, ellipsoidal, spherical, cubic, prismatic, roller, pyramidal, and so forth, a property depending on the original crystallization and cleavage. It influences the settling velocity, because the surface area depends upon the shape. The sphere, with smallest surface area for a given volume,

6 Krumbein and Pettijohn (1938), chapter 9.

7 Krumbein and Aberdeen (1937); Krumbein and Caldwell (1939); Krumbein (1939).

8 Mackie (1897); Ziegler (1911); Galloway (1922).

9 Twenhofel (1939); page 230.

10 Summarized by Pettijohn in Krumbein and Pettijohn (1938), chapter 13.

has the highest settling velocity, and was therefore used to name the shape function, sphericity, chosen as 1.0 for water.

Roundness, on the other hand, depends on the gradual reduction of sharp angles along corners and edges. Rounded grains will move more easily in the traction load. A rolier shaped pebble has a low sphericity but a high roundness. A trapezohedron of garnet sand may have a high sphericity, but be completely angular, that is, of zero roundness.

Wendler[11] studied shape of grains from the basal Catahoula sandstone of Fayette County by the Tester method, and concluded that they were pointless for correlative purposes. Hagerman (1933, 1936), however, claims that he has succeeded in stratigraphic correlation with his techniques. More shape studies are needed.

The surface texture of sand grains has received little study, so proof of the genetic significance of texture is lacking (Williams, 1936-37), but opinions are not. Sherzer[12] attributes the frosting of sand grains to aeolian action. Krumbein (1943) says: "Polish may be produced by gentle attrition, by solution, or by the deposition of a vitreous film on the particle. Frosting may be caused by vigorous wind scour, by solution, or by incipient secondary growth."

In Texas, surface texture has been used to distinguish the basal Catahoula sandstone, known as the Chita formation, from other formations. Plummer[13] describes the "rice sands" of the Chita composed of polished translucent quartz grains, sub-angular to subrounded, with their angularity decreasing with increasing size of grains.

Much might be learned by conscientious study of the surface texture of sands of the Texas Gulf Coast.

The arrangement of grains in a sand has received little attention, except for the theoretical consideration of the packing of equal sized spheres, in which it has been pointed out that the porosity can vary from 47.64% to 25.95%, depending upon whether square or rhombic packing is attained (Graton and Fraser, 1935).

The fabric of sands may conceivably be a fertile field of investigation, with practical results in determining currents and agents of the ancient environments, and the relation of fabric to storage and migration of oil. Orientation analysis is amenable to graphical treatment, but new techniques await development before data can accumulate.[14]

The porosity of a sand or sandstone is the percentage of pore space in the total volume of rock. It is one of the mass properties, dependent upon size, shape, sorting, packing and cementation of the grains. The pore space determines the volume of oil or water that may be stored in a sandstone reservoir. The oil companies have determined porosity along with permeability in their laboratory analyses, but this information has, in general, not been published. Downdip porosities of the Wilcox sandstone at depths from 7,630 to 10,150 feet average 197, with a variation from 7% to 23%, as recorded from 14 wells by Culbertson (1940). According to Todd and Roper (1940), the producing Sparta sands show porosities averaging 18 to 20%.

11 Wendler (1934), page 140.
12 Scherzer (1910), page 640.
13 Sellards, Adkins and Plummer (1932).
14 Krumbein and Pettijohn (1938), chapter 10.

The permeability of a sand is the ease with which it transmits fluids. A simple formula for permeability, P, used by ground water engineers, is

$$P = \frac{Q}{IA}$$

Q is the volume of fluid flowing in unit time.
I is the hydraulic gradient (loss of head per unit length).
A is the cross-sectional area.

The average laboratory permeability of the Wilcox sands is 156 millidarcys in the determination of Culbertson (op. cit.) and of the Sparta sands 400 millidarcys according to Todd and Roper (op. cit.) On large cores of the unconsolidated Queen City sand from Bastrop County, Plummer and Tapp (1943) achieved a radial permeability of 1,936 millidarcys averaged from 7 samples.

Ground water engineers and geologists now make accurate transmissibility tests (permeability x saturated formation thickness) of aquifers by the drawdown and recovery of a pumped water well (Wenzel, 1942). Such tests in the Houston district give a transmissibility average of 145,000 gallons per day per foot for six new wells in the Southwest field producing from multiple sands (probably Lissie) screened at depths between 550 and 1,500 feet (Lang, 1946).

A strange result of high transmissibility is quicksand. Quicksand at the surface has been known to engulf horses, cattle, sheep, hogs, human beings, and even a train which jumped a bridge near Pueblo, Colorado in 1875. Quicksand in building foundations is a difficult nuisance, and quicksand in shallow wells is a problem in casing and cementing off. Quicksand has been attributed to rounded sand grains, and to a shift from loose pack to close pack of the grains, but the most lucid explanation is the Hazen[15] theory that quicksand is formed by the upward movement of water of a spring, which lifts the grains apart. This explains, also, why quicksands are mostly fine-grained, since upwelling water is seldom strong enough to separate a medium or coarse grained sand. It explains, too, why sands in the hollows and draws are quick only during the wet seasons, as a rule.

Burt (1927) writes of seasonal quicksands in the creek bottoms of Brazos County, Texas, and they are undoubtedly common in other parts of the coastal plain. What loss they cause the Texas ranchmen is not known.

The specific gravity of quartz, the chief component of sand, is 2.63. However, the bulk density of sandstone in gms/cc varies from 1.4 to 2.7, and averages 2.4.[16] Since this is about the average of rocks as a whole, it indicates that by itself sandstone causes no gravitational anomaly, and will not be detected by gravity instruments, except as it is thrown in structural contrast with low-gravity salt, or high gravity igneous rocks.

Furthermore, the magnetic susceptibility of sandstones is inconspicuous, being about 15 x 10^{-6}.[17] Therefore, no magnetic anomaly is

15 Hazen (1900); Smith (1946), 1946a, 1947, 1947a).
16 Heiland (1940), pp. 75, 83.
17 Heiland (1940), p. 312.

detected from sandstones except as they conform to magnetic structures.

Sonic velocities of sands in feet per second vary from about 1640 to 3280, and of sandstones from 3,000 to 14,000. For the Texas Gulf Coast, the Upper Miocene varies from 7,874 to 8,858 ft./sec., while the Middle Eocene is 13,780 ft./sec. [18] Further study of sandstone velocities in the Gulf Coast might be molded after the Cooperative Well Velocity Surveying Group of California (Olson, 1941).

Resistivities in ohm-cm. of sands vary from 10,000 to 100,000 and of sandstones from 3,500 to 400,000. [19] These are averages from outside the Gulf Coast, and it would be interesting to compare tabulations of resistivities for the many sands found in the Gulf Coast. This is, of course, done every day in offices of oil companies, where electric logs are correlated over many sections and fields.

The radioactivity of sands has recently become important, chiefly in determining the location of sandstones on a radioactivity log. Russell (1944) has found from Geiger—counter determinations of gamma ray activity of 510 sedimentary rocks, the following average, measured in radium equivalents of 10^{-12} grams of radium per gram of rock: shale 12.0, sandstone 4.1, and limestone 3.1. This radioactivity is due to potassium and to members of the uranium-radium and thorium series. The potassium is present in feldspar, mica and glauconite. Rare monazite or carnotite sands may be more radioactive.

Structures of sands are the large features of deposition and deformation which sands exhibit. Bedded structures predominate, although sands are occasionally massive. The sands may be cross bedded: irregular and high angle, indicating wind agency; even and low angle indicating water agency. Sands may be lenticular, as in deltas. They may wedge-out, to form important stratigraphic traps, like the great East Texas oilfield, formed on the wedge-out of the Woodbine Cretaceous sand. Faulting may form reservoir traps in sand. Folding may dome sandstone, or arch it into a closed trap. Sandstone dikes may intrude and fill fissures. Shore and bodies, such as beaches, bars, spits and tombolos, may become important oil traps (Brewer, 1928).

The geological environments of sand deposition are chiefly desert, river, littoral and delta. [20] The sources of sand are chiefly the granitoid igneous rocks, the gneissoid metamorphic rocks, and older sands and conglomerates. The agents are chiefly water currents for the coarse, medium and fine sands, and wind and water currents for the very fine sand. Deposition depends on the settling velocity, a modification of Stokes' law, that settling velocity is proportioned to the square of the nominal radius of the grain. Sorting of sand, therefore, takes place, according to size, according to specific gravity, and according to shape.

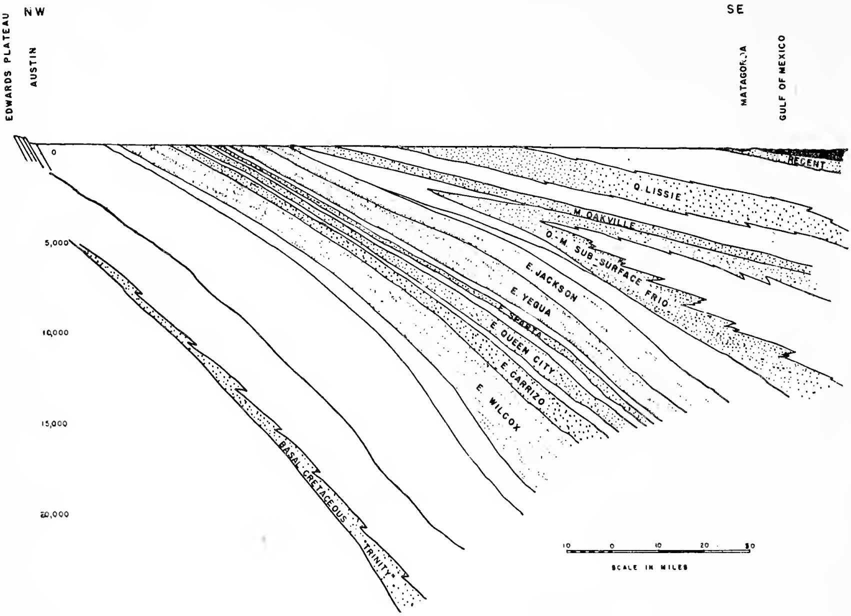
Post-depositional changes of sand may be diagenetic or epigenetic, and they involve compaction, cementation, with reduction of porosity and permeability, and the growth of concretions.

The areal distribution of sands and sand-stones in the Texas Gulf Coastal Plain is shown on the geologic map. The persistence of most of

18 Heiland (1940), p. 470.

19 Heiland (1940), pp. 662, 664.

20 Twenhofel (1939), chapter 3.



SANDS OF THE TEXAS GULF COAST

these sands along the whole arching strike of 500 miles is indeed remarkable. The Carrizo sand, the Sparta sand, and the Lissie sands, for example, are remarkably persistent. True, there are some sands which are highly lenticular, for example, the sand lentils of the deltaic Wilcox and Yegua, which are interbedded with shales and lignite.

The vertical distribution of the sands is suggested by the diagrammatic cross-section, figure 1, taken on a southeast line from Austin to Matagorda, which illustrates the approximate outcrop sequence along the Colorado River from the Edwards Plateau to its outlet into the Gulf of Mexico. Horizontal control is furnished by outcrop boundaries on the geologic map of Texas, and vertical control is taken for the Yegua formation on to the coast from the electric logs of deep wells interpreted by Deussen and Owen (1939).

This diagram emphasizes only the sands; the shales comprise the intervening white areas, except those of the Cretaceous formations below the Eocene, which are marls, chalks, limestones and dolomites as well. The vertical exaggeration of the diagram is considerable: actually the surface dips are only 1° to 2°, and the subsurface probably seldom more than 5°.

The prevailing dip is gulfward, and suggests that a huge earth basin is in the process of filling. This basin has been called the Gulf Coast geosyncline by Barton,[21] who believed that the subsidence is due to the sedimentation, and the sea deposits overlap the margin when subsidence is more rapid. This idea has been challenged by Sheets (1948), who

21 Barton, Ritz and Hickey (1933).

contends that the basin has been stable since the dawn of the Cenozoic with progressive backfilling since. The following are criteria on which the question will resolve: if sedimentation-subsidence is true, then the deeper sediments will have subsided far beyond initial dip, and there should be a line of flexure, along which the rate of dip increases rapidly; if stable-filling is true, dips should be initial dips, even though somewhat higher for the older beds, and no flexure should appear. The diagram suggests that with our present data, the question is not yet resolved.

In the outcrop, sands comprise about half of the area of the Texas Gulf Coastal Plain. Since these sands grade into shales downdip, the actual proportion of sands is estimated to be only 30 percent. Still this is a ratio of sand about twice as great as sand usually makes among sediments as a whole. The prominence of sand is undoubtedly due to the persistence of delta and shore environments during coastal sedimentation.

Before a consideration of the uses of sand as a particulate substance is made, its more important use as a reservoir must be emphasized.

In Texas, the discovery of oil and gas reservoir sands is probably more advanced than in any area of comparable size in the world. Although thousands of wells are now producing in this area, it is estimated that an equal number remain to be discovered.

The sand aquifers of Texas yield large quantities of water: Houston, the industrial capitol of the Texas Gulf Coast, with a population of over a half-million, is perhaps the largest city solely supplied with water from wells. The potential ground water yield of the sand-water reservoirs of the Texas Gulf Coastal Plain is high, and the locale of future industry and settlement will be controlled by proper exploitation of this indispensable resource. Overpumping has already seriously affected the underground water surface in a few areas, notably Houston itself. Whether or not the safe yield has been exceeded is still under study. Proper conservation will have to be applied. It is not generally known that the location of large Army training camps, in this equable southland, was in every case determined by a favorable preliminary water investigation.

Although the reservoir uses of sands in Texas Gulf area are being vigorously applied, the industrial uses lag. Uses of sands for abrasives, foundry work, glass manufacture and filter sand have just recently been investigated and applied at the Corley deposit of Wilcox age in Freestone County (Hoeman and Redfield, 1943).

The engineering uses of sand for road metal and concrete aggregate, are adequate at present, and for years to come, in coastal Texas.

Quicksand in foundation structures can usually be overcome by grouting. Unfortunately, quicksand on ranches will probably never be overcome, for if the quicksand spring is cemented off, the water will simply take a new channel and emerge elsewhere. Livestock losses can be reduced only by fencing off areas which are quick in the wet season.

Texas has one of the unique uses of sand in the altered greensand iron ore (Eckel, 1938), the basis for the nascent Lone Star steel industry. This iron ore occurs in the Weches shale, between the Queen City and Sparta sands, throughout East Texas. Grains of greensand, a potassium iron aluminum silicate, with the mineral name of glauconite, weather in the outcrop to iron bicarbonate and clay. The iron bicarbonate is leached by ground waters and concentrated in certain beds as the iron hydrate, limonite, a brown iron ore. Thus the iron ore is limited in depth to the zone of carbonation, oxidation and hydration above the water table.

The specifications of sand for various uses are summarized in the following table from Forrester (1946):

A. No clay present.
   1. Grains of uniform size. (Uniformity of size is granted if 90% approach a specified dimension).
      A, filter sand; B, glass sand; C, sand-blast sand; D, stone sawyer's sand; E, grinding and polishing sand; F, carborundum manufacture; G, potter's sand.
   2. Grains may or may not be uniform in size.
      A, chemical and metallurgical sands; B, sand which is pulverized in certain uses; C, traction sand; D, sand-oil roads; E, stucco sand; F, roofing sand.
   3. Grains not uniform in size.
      A, sand-lime brick; B, asphalt pavement and flooring sand.

B. Clay may or may not be present. If present, it is in limited or specified amounts.
   I. Non-uniform in grain size.
      A, black mortar sands. Maximum amount of clay present is 3%; B, concrete sands. Clay not over 3% by weight; C, fire or furnace sand; D, core sand; E, plaster sand, clay up to 5% permissible; F, railroad ballast sand.

C. Clay present.
   1. Non-uniform in grain size.
      A, sand-clay roads; B, foundry (molding) sands. Should have 2 to 20% clay as bonding medium. An increasing amount of so-called synthetic moulding sand is being used. It is an artifical mixture of silica sand and a bond clay.

Our present sources and possible sources of information on sand of the Texas Gulf Coast may be summarized in a few paragraphs.

The American Association of Petroleum Geologists publish a monthly bulletin, and occasional texts, on oil reservoirs, with considerable reference to sands of the Texas Gulf Coast.

The larger oil companies have taken many measurements of porosity and permeability on sand cores in their laboratories. Much of this information is no longer confidential, and it could possibly be collected so that overall maps of these mass properties could be made for each sand.

The Texas Board of Water Engineers in cooperation with the Ground Water Division of the United States Geological Survey have published many reports on the sand aquifers, including location of water wells, water quality, and sand permeability.

The Bureau of Economic Geology, University of Texas, have published excellent bulletins on the geology and mineral uses of the sands. The United States Geological Survey has supplemented this work.

Geophysicists have assembled a mass of information on the reflection and refraction of sands, determining particularly the velocity of sound in various sands, and have published a small portion of this storehouse of fact in the journal "Geophysics." Some release and analysis of this data might be of interpretative value, indicating increasing cementation with depth, variation of hardness along the strike, channels of cementation, and other pertinent facts.

In retrospect of these sources, it is apparent that more correlation of acquired data is paramount. Moreover, more petrographic studies are desirable. A few texture and heavy mineral studies were made in the twenties and early thirties, but because too few samples were taken, too few studies made, and statistical analysis was too undeveloped, little was derived from this preliminary attack. The electric log, and the Geiger counter furnish us with two new tools which can reveal much about sands. The maps of the variation in resistivity of sands, along strike and dip, might be illuminative. More industrial analyses of sands should be made and recorded.

Perhaps a clearing house, a "Committee on Sands," or a bureau on sands would be the answer to more integrated attack on the sand problem. Interest must be stimulated, discussion aroused, and genuine awareness achieved, on the importance of study and use of sand, before any real program may be made.

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EDITORIAL NEWS AND NOTES

THE EDITOR has received an invitation from the Biological Abstracts to forward to them author's abstracts of all papers published in the Journal. All of you are familiar with Biological Abstracts and we are sure that you will wish to avail yourself of this service.

THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS was founded many years ago and is one of the outstanding scientific bodies in the United States. Each year they hold an annual convention. Last year it was in New Orleans, this year it will be in Washington, next year, we believe, it is going to be on the West Coast. It seems to us that this convention might well be held in Texas in 1950. The Texas Academy of Science could well take an interest in this matter.

MR. JOEL HEDGPETH, of the Marine Institute of the University of Texas, will spend the summer in California where he has a teaching engagement at the Pacific Marine Station, Dillon Beach, California. Mr. Hedgpeth is engaged in working up a badly needed monograph on the invertebrates of the Texas Coast.

THE SECTIONAL MEETING at Corpus Christi was well attended and a number of exceedingly interesting papers were presented. The joint meeting with the A.A.A.S. at Alpine was also well attended, and President Eby says that there was a fine program with many excellent papers.

THE ANNUAL MEMBERSHIP LIST of The Texas Academy of Science, along with the reports of various officers will appear in Volume I, Number 3, which will be out September 30.

THE MARINE LABORATORY OF THE GAME, FISH AND OYSTER COMMISSION is making arrangements for a biannual seminar and field study to be held at Rockport October 23 to 29, 1949 and April 23 to 29, 1950. This seminar and field study is designed to offer to colleges and universities of the state a well rounded program twice a year. Twenty-four hours of lecture and twenty-four hours of field study will be planned for each session of seven days.

Tentatively, the lecture subject matter will include geology of the coast, oceanography, engineering as applied to marine structures, chemistry and commercial utilization of sea water, marine bacteriology, plankton studies, coastal botany, marine invertebrates, parasitology, pollution, ornithology, mammalogy, special subjects, physiology and investigational methods and equipment. Lectures will be given by specialists in the field and tentative dates have already been made with such men as Dr. Willas G. Hewatt of Texas Christian University, Dr. Frank Blair, Dr. O. B. Williams and Mr. Joel Hedgpeth of the University of Texas, and Dr. W. B. Davis of Texas A & M to present lectures, and acceptances are coming in rapidly from other outstanding men in the various fields.

Because of the shortness of the course it will be necessary to confine the attendance to students of at least Junior standing and who are majors in biology or some closely related field as this will eliminate much unnecessary introductory work and will allow the lecturers to pursue their subject directly, with a minimum of introductory material.

THE RICE INSTITUTE has extended an invitation to the Academy to hold its annual meeting in the new Fondren Library in December. At the Executive Council meeting held on May 23, this invitation was accepted by President Eby and the council.

DR. C. M. POMERAT, executive vice president of the Academy and head of the tissue culture laboratory at the Texas University School of Medicine, is leaving this summer for an extensive trip through Europe.

DR. L. W. BLAU has kindly consented to edit The Texas Journal of Science, during June, while Mr. Baughman is absent. Mr. Baughman will attend the Oyster Convention at Old Point Comfort, Virginia and then visit a number of the eastern laboratories.

DR. THOMAS KNIGHT CHAMBERLAIN, of the Division of Fishery Biology, Fish and Wildlife Service, U. S. Department of the Interior, has been assigned to headquarters at Stillwater, Oklahoma, where he will have his office with the Oklahoma Cooperative Wildlife Research Unit. Dr. Chamberlain, working on problems connected with large water impoundments in Oklahoma under the joint supervision of the Oklahoma Game and Fish Council and the Fish and Wildlife Service, is also serving as Assistant Unit Leader, Oklahoma Cooperative Wildlife Research Unit. He has also been appointed assistant professor in the Department of Zoology at Oklahoma Agricultural and Mechanical College.

THE MARINE LABORATORY OF THE TEXAS GAME, FISH AND OYSTER COMMISSION has recently added Mr. William L. Haskell, Mr. A. W. Anderson and Miss Cecelia Wright to its staff. Mr. Haskell, a graduate of Oregon State College, will be occupied with a survey of the shell and oyster resources of the state; Mr. Anderson, a graduate of Texas University, with an economic survey of fisheries and Miss Wright, a graduate of Our Lady of the Lake, will be laboratory assistant. Mr. Joseph P. Breuer, of A. & M. and Robert J. Kemp, of Texas University, will also work for the summer on the menhaden project, Mr. Breuer at Port Arthur and Mr. Kemp at Port Aransas.

DIRECTIONS FOR THE PREPARATION OF MANUSCRIPTS

1. Manuscripts should be submitted to The Editor, Texas Journal of Science, Box 867, Rockport, Texas. Manuscripts may be subject to minor editorial alterations in order to conform to the general style of the Journal. All manuscripts must be typewritten and double spaced with wide margins. The fact that a footnote is usually printed in small type, closely spaced, does not make it any less likely to need correction than any other portion of the manuscript, and the practice of some authors to single space such interpolations makes it exceedingly difficult to make the necessary editorial corrections.

2. Each manuscript must be accompanied by two copies of an abstract, not more than two hundred and fifty words in length. If the editorial board finds it advisable, the abstract may be published instead of the paper. If the paper can be much improved or condensed the editor may return it for such changes.

3. The following form should be adhered to in typing any paper:—

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Name of Author
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4. References or bibliographies should be arranged alphabetically at the end of the article, without numerical designation. References in the text should be by author's name and date of publication.

The use of footnotes should be avoided wherever possible. These are troublesome to the editor, and a nuisance to the printer, as they have to be properly spaced in the composing, which takes increased time and raises costs.

5. A typical bibliographical entry should be as follows:—

Doe, John, and **W. C. Rowe**—1943—How to prepare a bibliography. Tex. J. Sci. **6**(2): 1-13, 3 figs., 2 pls.

—————————— 1943a—How not to prepare a bibliography. Tex. J. Sci. **3**(1): 1-26, 2 figs., 3 pls., 2 maps.

—————————— 1947—Mistakes often made in preparing a bibliography. Tex. J. Sci. **1**(1): 7-15, 2 pls.

The above is a standard form that makes it immeasurably easier for the editor to handle. Please be accurate about the volume, part and page numbers. A poor bibliography is worse than none at all.

6. Cuts and other figures will be accepted up to the limit of the Academy publishing budget. However, for the present it is desirable that they be kept at a minimum. All illustrations should be in black and white for zinc cuts where possible. Half-tones require special paper and, if too expensive, may be charged to the author. Drawings and illustrations should be carefully prepared for reproduction. Legends should be precise and included with the drawing and illustration.

7. Tables should be limited to necessary comparisons and, if possible, should be clearly typed or hand lettered ready for photography. Printing tables is very expensive.

8. Arrangements are being made with the publisher to furnish three sets of proofs to the editor so that one may be sent to the author for proof reading before publication. However, until we are able to get a sufficient mass of type set ahead, it will be very necessary to return this corrected proof and manuscript promptly or the paper will have to be omitted from that issue of the quarterly and another substituted on which the author has been more prompt. Moreover, remember that extensive changes in the subject matter of the paper after the type has been set are expensive, and time consuming. If such changes must be made the expense will, of necessity, fall on the author.

9. Arrangements are being made to furnish reprints. The following schedule of prices will apply, subject to change. They are identical with those charged by Copeia, the official Journal of the American Society of Ichthyologists and Herpetologists. It will be necessary for a check to accompany orders for reprints, which may be returned with the proof. This, of course, does not apply to institutional orders, but only to Academy members ordering personal copies. This keeps bookkeeping at a minimum and also keeps the publisher in a good humor. It is felt that this is the most desirable way to handle the matter despite the fact that in the past it has been the custom for the editor to obtain the reprints from the publisher and then collect from the individual member.

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ORGANIZATION: The activities of the Academy embrace all scientific fields. In the Senior Academy, there are five Sections: Physical, Biological, Social, and Geological Sciences, and Conservation. Regionally, the Senior Academy is divided into three branches: East Texas, South Texas and West Texas. The Collegiate Academy promotes the organization of science clubs in colleges and universities. The Junior Academy encourages scientific activities in secondary schools.
MEMBERSHIP: "Any person engaged in scientific work, or interested in the promotion of science" is eligible to membership.
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WATER—AN INDUSTRIAL NECESSITY

Paul Weaver
Chief, Geophysical Department
Gulf Oil Corporation
Houston, Texas

• Water is basic to industry in two ways: first, there must be people to run the plant, and these people usually live in large groups, so that water is needed not only domestically, but also for group purposes, usually called public or municipal. Secondly, there are the requirements for water in the processes carried on in the plant.

There are several factors of quality of water which must be considered for each of these two main demands: For group use, we have two kinds: (1) domestic, which should "be clear, free of toxic materials, safe from a bacteriological standpoint, pleasant tasting, and relatively low in mineral content" (2) service use, which includes fire protection, street cleaning, cooling, and some cultivation, as on golf courses and parks. Service use does not require as high a quality as domestic use, but in most communities, it is uneconomical to have two separate supply and distribution systems, so that there is usually only one supply, and therefore it is necessary that the quality be satisfactory for domestic use.

Conservation could be introduced in this field of group use, by having a supply of less desirable quality for the service uses. This would require duplicate supply systems, and is not really necessary, if the effluent from the public system is properly handled, so that it can be available for use again downstream. Most of the water from such a system goes to a sewage treatment plant, and therefore is properly treated.

What is the measure of demand of this kind of water? The average use in East Texas public systems in towns which do not supply special industries is about 45 gallons per capita per day, but as cooling systems become more generally used, this demand will increase, particularly if there be used evaporative systems. The amount of water required for cooling depends much upon the temperature of the water supply, as well as upon the air temperature and humidity. A conservation of this cooling water will be effected by the most efficient systems, but at a considerably larger cost than desert cooler types. It seems very likely that with increase in comfort in offices and homes, and with greater use of sprinkling systems in cleaning streets, public use even in the smaller Texas towns may soon exceed 100 gallons per capita, or about double present average rate, but it should be remembered that most of this water will re-appear in the sewage collection plants, and that it is not a net use.

For the industrial plants themselves, the quality of water required is also in part of a high order. Water is used in boilers, in the cooling of heat exchangers, in the processes themselves; there are also maintenance operations such as cleaning, fire protection, and air-conditioning, which correspond to service uses in cities.

For industrial water, objectionable qualities of water are: "high hardness, excessive qualities of organic matter, high bacterial counts, abnormal pH values, and high salt content." In some uses in the plant, the incoming temperature of the water should be constant and low, which accounts for the preference so frequently shown in Texas to the use of water directly from wells instead of from surface supplies.

The quantity required is dependent principally upon two factors: (1) the amount needed for steam in the boiler plant, and (2) the amount actually used in the industrial process itself, where the property of water most useful is its solvent and diluting effect. Every industrial process, and they are legion in the chemical industry, which requires that a substance be treated first with an alkali and then with an acid, or vice-versa, usually involves the use of water as a solvent; there is left in the water all of the acid or the alkali removed from the substance, thereby resulting in the pollution of the water so that it is not generally available for further use, and in some cases so that it is a nuisance when delivered into natural water courses. Therefore, use of water in the industrial process may be considered a consumptive use, if the effuent is unfit for other use. In many plants, the water is so dilute that it is still suitable for use, and therefore its employment is non-consumptive. The dilution is great enough in many plants to account for the very large volumes reported in some industries, such as 65,000 gallons per ton of steel. Although such quantities pass into the steel plant, most is delivered out in a dilution still suitable for some other use. We need to have statistics, not only of volume of water required to deliver into our industrial plants in Texas, but of the volume of usable water out of the plant, before we have the true picture. If water is subsequently treated, instead of merely diluted, conservation will be greater.

The volumes required in industrial manufacture in Texas have never been tabulated, but some figures per capita of population in the industrial areas, including both domestic and industrial use, are available. Houston now uses daily about 133 gallons per capita, Texas City about 1100, Tri-Cities about 2600.

I believe that for an industrialized area, about 400 gallons should be provided for, and if the industry is mostly chemical, about 1,000 gallons per capita per day.

What is being done to make inventories to determine where these quantities are available? Governor Jester has called five water conferences during the past year: West Texas area, held at Big Spring, January 20, 1948; East Texas, held at Tyler, May 21, 1948; Central Texas, held at Waco, July 8, 1948; South Texas, at Corpus Christi, August 13, 1948; and Gulf Coast, at Houston, October 20, 1948. At these meetings, the State Board of Water Engineers, State Health Department, Fish, Game & Oyster Commission, the United States Geological Survey's division of water resources, municipal, water districts and private industrial users have all contributed to the discussion.

To effect the greatest use of all water supplies, there must be the sound adjudication of water rights, the determination of beneficial use under these rights, and the scientific authorization of proper operation of the engineering works which gather, store, and distribute the water; finally, the treatment of the water after use to minimize consumptive use, and to make available for further use water used non-consumptively. The Texas Water Conservation Commission has been reviewing the laws of Texas and other Western States, to determine what changes in present laws will help in the program just enumerated, and during this year has prepared a new surface water code, and is studying a new underground water code. (See Editor's note below). Important engineering works which are vital to further use of all of our water have been considered in these new codes, and include:

(1) Storage of flood water. Present legislation is primarily concerned only with normal stream flow. Although these works are of great value when the storage is in reservoirs, it must be remembered that in Texas the rate of evaporation from water bodies is high; also because of the frequency of heavy rainfall, erosion of exposed lands results in siltation down stream in the reservoirs.

Artificial underground recharge into ground water reservoirs is an alternative to surface storage, and is assuming importance in our national picture. Dr. Sayre expressed the present view: "Although artificial recharge is not everywhere feasible, and in many places is not necessary or practicable under present conditions, it has been eminently successful in a number of places where it has been attempted. It is believed that as the use of water approaches the available supply . . . artificial recharge will assure increasing importance in our national economy."

(2) Construction of wells so that they prevent inter-connection from underground strata at several levels and with the surface.

(3 Operation of wells so that operating levels are not greatly below static levels, both for prevention of lower more mineralized water entering the well, and to assure against subsidence.

(4) Minimizing transmission losses in canals, water mains, and sewers.

(5) Use of water not of a quality for general domestic and industrial use for special purposes where high quality water is not imperative.

The decision to embark on some of these types of water engineering will depend very definitely on the adequate adjudication of the property rights and other State authorizations which are involved, and the codes are being drafted with this in mind. Secondly, it will depend on the complete assemblage of data of rainfall, humidity, evaporation, stream flow, and water yields from wells, as well as the complete coverage of the State of Texas by soil and geological surveys.

Great educational value has been the result of the efforts of the State Board of Health, the Fish, Game and Oyster Commission in the field of pollution and contamination; surveys by the United States Geological Survey, the Reclamation Service, the Army Engineers, and the State Board of Water Engineers are increasing the basic data, but much remains to be done before we have an inventory of Texas water.

(Editor's Note: The 51st Legislature did not pass any of the recommended laws, except one providing for the creation of artificial underground recharge districts on a local option basis. (House Bill No. 162). The Legislature, however, recognized the importance of modifications to the present laws, and set up a special interim committee to study the entire field of water legislation. (Senate Concurrent Resolution No. 36).)

SOIL AND WATER CONSERVATION—AN ECONOMIC AND SOCIAL NECESSITY

Roy L. Donahue
Extension Agronomist
Agricultural and Mechanical College of Texas

It is essential that people, both rural and urban, have adequate incomes. Rural and urban income is derived in a large part from the primary and secondary products of the soil—primary products such as corn, and secondary or manufactured products such as corn starch. As productivity of the soil decreases, incomes shrink. As incomes decline, as a consequence of reduced productiveness of the land—so often due to soil neglect—the farmers and city people both suffer. Thus we see the ultimate effect of a chain of circumstances initiated by rain drops beating bare soil into mud puddles, causing erosion, soil depletion, reduced yields, less grass for the cattle, lower incomes, and more misery.

For generations, agricultural and social leaders throughout the South have witnessed a farm economy based on the production of a single cash crop such as cotton or tobacco. Under a cotton economy, the South prospered in former generations; but, as necessity forced farmers to bring into cultivation even steeper hillsides and poorer soils, they were utilizing to the limit—even to destruction—their greatest asset, the topsoil.

It is apparent to anyone who has studied the soil that there is a definite relationship between the productivity of the land and the welfare of people. Let the good earth produce! This kinship with its attendant responsibilities of man and soil is aptly stated in this manner:

The Earth is the mother of us all—plants, animals, and men. The phosphorus and calcium of the earth build our skeletons and nervous systems. Everything else our bodies need except air and sun comes from the earth.

"Nature treats the earth kindly. Man treats her badly. He overplows the croplands, overgrazes the pastureland, and overcuts the timberland. He destroys millions of acres completely. He pours fertility year after year into the cities, which in turn pour what they do not use down the sewers into the rivers and the ocean. The flood problem insofar as it is man-made is chiefly the result of over-plowing, overgrazing, and overcutting of timber.

This terribly destructive process is excusable in a young civilization. It is not excusable in the United States in the year 1938. We know what can be done and we are beginning to do it. As individuals we are beginning to do the necessary things. As a nation, we are beginning to do them. The public is waking up, and just in time. In another 30 years it might have been too late.

The social lesson of soil waste is that no man has the right to destroy soil even if he does own it in fee simple. The soil requires a duty of man which we have been slow to recognize.

In this book the effort is made to discover man's debt and duty to the soil. The scientists examine the soil problem from every possible angle. This book must be reckoned with by all who would build a firm foundation for the future of the United States.

For my own part I do not feel that this book is the last word. But it is a start and a mighty good start in helping all those who truly love the soil to fight the good fight."*

In the sound track of his American documentary film, "The Land," Robert Flaherty puts the whole thing very simply: "If the soil does not have it in it, the plants that grow there do not, or the animals that eat those plants, or the people who eat those plants and animals."

THE SOIL CONTROLS THE BODY. HUMAN DEFICIENCIES POINT THE WAY BACK TO THE SOIL, NOT TO THE DRUGSTORE.

Milk is no better than the feed the cow has eaten. The amount of calcium in a lettuce leaf may vary as much as sixty-fold, depending on the soil from which it grew. There are parts of Florida specializing in truck crops for the markets, where the soil lacks iron—so does the food raised—and many of the people eating this food suffer from anemia. Phosphate deficiencies, reflecting themselves in bone and breeding troubles among livestock, are very common. In Texas phosphorus deficiency in advanced stages is called "creeps" or "loin disease"; in Alabama, "creeping sickness" or "sweeny."

Plants require eighteen or more kinds of elements. The elements most likely to become exhausted are nitrogen, phosphorus, potassium, and calcium; and in any program of soil replenishment, phosphorus is indeed the key. "Recently," says W. M. Landess of the TVA staff, "I showed a group of farm women two bones. We put them on a scale and weighed them. One bone weighed twice as much as the other. They were thigh bones from Jersey heifers a year and a half old. Both animals were fed the same ration which was low in phosphorus, but one was given a supplement of mineral phosphorus. This was in an experiment at the University of Minnesota. After studying the two bones, one of the homemakers said, 'I know some people I've considered onery. Now I see that perhaps they just don't have what it takes.' "

THE APPROACH TO A CURE—UNDERSTANDING OUR SOIL

We have become so accustomed to concrete and steel, automobiles and airplanes, and the comforts and luxuries of our modern life, that we are prone to forget our dependence on the soil.

So important are the few inches of earth which produce our food, clothing, and most of our shelter that the topsoil has been compared with the placenta which nourishes the unborn child. But unlike the child, we are never freed from our dependence on the earth's placenta.

There was a time in man's history when he, like the animals of the forest, had to spend all his time seeking food and a means of protecting himself from the weather. As recently as the time of Columbus, 19 out of every 20 persons were engaged in the production of food, clothing, and shelter. Today, in the United States, because of the development of our scientific agriculture and because of our bountiful soil, one farmer is able to produce enough food for his family and for five other families.

MAN AND HIS ASSOCIATION WITH THE SOIL

There is at least a little love of the soil and of growing things in *all* of us—there is a lot of love of the soil in *some* of us. It is truly astonishing how

* This statement is from SOILS AND MEN, Yearbook of Agriculture for 1938.

much we are all gardeners. From the window box to the farm, and from the suburban garden to the great ranch—flowers, fruits, and vegetables sprout up and grow. Nor are these masters of growing things always "countrified" people. On the contrary, the plants are often tended by hands accustomed to grease and wrenches, or cared for by hands that spank the next generation into the straight and narrow path. This is very heartening. It makes one people of all of us!

The failure to maintain an average crop yield over a period of years is usually blamed on the soil. As a matter-of-fact, a crop of corn or cotton is a product of the joint efforts of man and soil. Such a failure, therefore, may be due to the man or to the soil or to their joint effort; in the last case, the blame being on the man for he is the intelligent and directive head of the partnership. The failure on the part of the man may be due to the fact that he has selected a soil unsuited to corn or cotton, or, having selected a proper soil, he may have failed to manage the soil intelligently. On some soils it is almost impossible to make a living.

When a soil is referred to as a tool in the hands of a man to accomplish something with, it is not a simple tool such as a saw or a plane, but a highly organized tool such as a factory or an engine or an animal.

Soil types differ in their character and in their ability and capacity to perform service, just as factories and engines and animals differ. They each require different care and treatment, and it is upon the recognition and use of these differences in capacity and treatment that ultimate success depends. In the modern concept of the soil, man has a leading part. He is the intelligent and constructive partner in the use of the soil—to make it productive or to destroy its usefulness.

MAN'S USE OF FERTILIZERS

Our farmers today have become familiar with the terms 'nitrogen,' 'potash,' 'lime,' and 'phosphate,' because they have been taught that these substances in the soil constitute a valuable part of the food of plants and they have come to apply different compounds of these materials to their crops in commercial fertilizers. Nitrogen was unknown, however, until the year 1772. While 'glowing' phosphorus was known to the old alchemists and was used in some of their mysterious rites, it was so difficult to prepare that as late as 1730 the price was extremely high, and it sold in London for 10 to 16 shillings per ounce. The occurrence of calcium phosphate in bones was not known until 1769, and it was first obtained from bone ash in 1771. Potassium was not discovered until 1808. So we see that it has been only within a comparatively few years that knowledge of fertilizers and their use has been available. Now we can plan intelligently for overcoming the menace and threat which the soil presents to one who wants to go beyond the subsistence level of production on naturally unproductive soils, or to make productive soils even more productive.

It was not until Liebig's classical work in Germany was announced in 1840 that any scientific consideration was given to the study of the soil in its relation to crop production. Liebig pointed out that certain newly discovered materials such as nitrogen, phosphoric acid, potash, lime, and other substances were essential to the growth of plants. Liebig's "Law of the Minimum" is a classic. This law says that plant growth is limited by the one element most deficient.

TRAGEDIES OF THE SOIL

In all life the things that impress themselves upon the human mind are the tragedies—the quick and sudden changes from life to death—rather than the slower changes involved in most natural processes. The impressive things in the history of the world are the wars and revolutions leading to the overturning of nations or the overthrow of political parties. Gradual evolution of our civilization continuing through the centuries may be more important but is less spectacular. Less interest is shown toward inventions and philosophies that, working through mental revolts and intellectual wars, have made it possible to overcome and to overthrow ignorance and superstition and to bring about control and development of a more progressive society.

In the days of the old sailing vessels, the Goodwin sandbars off the English coast were known as a graveyard of ships. The sandbars still remain a menace to commerce and navigation. They represent an irresistible force of quicksands that engulf vessels that are once caught. The disasters and the tragedies associated with these sands have become a part of history, poetry, legend, and fiction.

The Goodwin sandbars constitute a great sand bank some eight miles long and about 4 miles wide. At high tide these sands are completely covered with water to a depth of about six feet; at low tide they project some six feet above the water's surface. When exposed above the water the sand is hard and firm and one may walk for miles as on hard beach sand. As the tide rises, the sand gets soft and the feet sink rapidly. In 1703 it is reported that 13 men-of-war were wrecked and disappeared in the quicksands. What a world of tragedy is written in this stretch of sand, the properties of which are not understood and have not been conquered in the ages that have passed since England's maritime trade has been developing.

The Goodwin Sands are feared and avoided, if possible, by all people who travel by sea because of the tragedies that have occurred to life and property through the awful forces operating in them. In many respects, the Goodwin Sands are like the Norfolk soils of our southern Gulf coast. These Norfolk sands appear peaceful, harmless, and serene; yet it is safe to say that they have caused more tragedies in the loss of life and property through ignorance of their strength, resources, and weaknesses, through loss of energy, loss of money, loss of hope, and loss of life, than have the Goodwin Sands off the English coast. The newcomer sees the Gulf coast sands mainly as they are farmed by those who have attained success. The newcomer may fail to understand the challenge or the menace, the mysteries, the strength, or the weaknesses of the land. The doom of the ship which strikes the Goodwin Sands is quick and awful in its destruction of life and property. The doom of a man who is shipwrecked on a poor sandy soil is slow, enduring, and commonplace. His final chapter is not spectacular, is not recorded in literature, and seldom stands out as a signal to warn other men to avoid the paths that he has followed.

WISE USE OF THE SOIL

In the care and use of the soil there are enemies to overcome and to overthrow, if success is to be attained. Each individual soil must be studied, also its resources and possibilities; its menace and weaknesses must be understood to gain ultimate success. In spite of the teachings of the agricultural colleges and experiment stations, of the Department of Agriculture, of the county agents, of the vocational teachers, and of the farm organizations, there is an inertia among people that is difficult to overcome.

We have demonstrations of the best known ways of doing all farm jobs a little better. We in the Texas A&M College Extension Service have pasture demonstrations, hog demonstrations, corn demonstrations, as well as demonstrations on the best ways to preserve food, harvest hay, and apply fertilizers. Farm unit demonstrations are also setup on a whole farm basis to point out to our rural people a better, cheaper, or easier way to do certain jobs, and to teach better farming and more pleasant living.

A few devoted men and women in all localities see the need for improvement and uplift in life of the individual, in care of the property, and in business methods, but their efforts are generally unorganized or the problems so complex that progress is slow. Our schools and colleges, churches and societies, community centers and business organizations are all working for the uplift of society, but for the most part the problems seem so commonplace to the individual or so involved that his interest is not aroused, and things are permitted to go on about the same as in grandfather's day.

Our technology has improved markedly, but our ability to get along together as individuals, groups, states, or nations has not improved very much.

Should we not renew our efforts to study our mutual problems, set up goals toward which to work, then cooperate with anyone and everyone to conserve soil and water? It is a lifetime job.

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THE CONSERVATION OF POTENTIAL SCIENCE TALENT AMONG OUR YOUNG PEOPLE

Joseph Albright
Collegiate Section

Conservation is the act of protecting or guarding that which we have to the end that there may not come a day when we have not. Only in the last few decades has conservation and the necessity for it become meaningful to our average citizen. Yet most of us still think of conservation only in terms of natural resources such as coal, iron ore, timber, soil, and more recently, water. Even here the full meaning of conservation had not struck us as evidenced by the tremendous amount of material that was wasted at the close of the last war. But much less do we realize the necessity for, and the meaning of the conservation of our human resources.

As a result of the wholesale destruction wrought by the last war, many peoples of the world are learning the full significance of conservation; in fact, a great part of the world's population is wishing it had something to conserve. In less fortunate areas of the world people are slowly putting into practice some small measures of conservation, but indeed they are small in the light of what must be done. Nowadays we're all thinking of, and earnestly hoping for, success in attaining a united world. Certainly there is no specific key to success in this matter, for the aspects to be considered in a united world are too many and too varied. But if by some manner the peoples of the world can see fit to unite and to engage in world-wide cooperation, it will be of invaluable aid to a program of conservation. By establishing world peace never again need we witness the sweeping devastation of men and material. It is foolish to absolutely waste the natural resources which might be put to such good use by this generation and by the generations to come. It is even more foolish for each era of progress to be climaxed by a world-wide conflict wherein many of our potential leaders in all fields meet with death. It is imperative that we wait no longer in exercising protection of the world's resources, and particularly the world's human resources.

What we are concerned with at this time is the conservation of the human resource, science talent.

Primarily, real ability for creative research is rare, and since this is true, it is absolutely necessary that none of those who possess this talent go unnoticed, and be allowed to drift into some work not worthy of their peculiar ability without having had encouragement, stimulation, and opportunity to show this creativeness. A critical shortage of scientific talent exists in America today, and the state of Texas is no exception. The discovery and development of scientific ability among young men and women in this state's junior and undergraduate schools is a real need.

Secondly, there is urgent need at the present time—and there is no reason to think that the demand will be less—for well trained, well qualified research workers, and for gifted instructors in scientific fields. The military forces of this country urgently need research personnel. Industry of the nation is begging for adequately trained men and gifted scientists. Our huge industries here in Texas are eager to employ men who have thorough knowledge of science, and who are endowed with the scientific spirit, and who desire to seek out scientific truths. Yet they must be content to employ those who have only a vague idea of the meaning of research and have not been imbued with fundamental scientific principles. The demand for science-trained instructors in the schools of Texas is unprecedented. In some localities in this state the present method of teaching science is atrocious. The students emerge with absolutely no basis in fundamental scientific learning. They have very weak mathematical backgrounds. Much too often the application of scientific principles is stressed to the neglect of pure science, and emphasis is placed on the success of the individual financially rather than success in gaining knowledge and advancing scientific truths. It is in the field of teaching that the greatest advancement must be made if we are to conserve scientific talent among our youth.

Once we realize that there is definite need for the preservation of youthful ability, it becomes imperative that we establish adequate methods for recognizing such talent, and that we afford every possible means of encouragement, stimulation, and assistance to those in which it is found.

One very effective method of searching out those who show promise of good work in scientific fields is by conducting scholarship searches and contests such as that conducted by the Westinghouse Electric Corporation wherein each year students all over the nation compete for the forty Westinghouse Science Scholarships. This particular science talent search is limited to high school seniors. Annually 300 students making high ratings on the Science Aptitude Examinations are chosen. Among these 300, forty are declared winners and are awarded scholarships, the remainder receiving honorable mention. To be named a winner or an honorable mention in this Science Talent Search is one of the highest recommendations for admission to the leading colleges and universities of the country. Entries in this particular search are made available to cooperating agencies and committees in various states to be used in state Science Talent Searches coordinated with the national competition. By entering the national Science Talent Search conducted by Westinghouse, students automatically enter searches in those states where this cooperative venture is in operation. Several of the state academies of science award state scholarships and give other honors. For instance in 1947 the academies of science in Alabama, Georgia, Illinois, Iowa, Louisiana, Tennessee, and Virginia held such cooperative state Science Talent Searches. Thus, any student in those states entering the national competition was automatically entered in the state competition. All entrants in those states had a double opportunity for scholarships or other recognition that would further their careers in science.

But this one particular program instigated and administered by Westinghouse should be only a beginning. Other large industries should follow the lead and establish programs of their own. Large research foundations and other scientific institutions such as our own Texas Academy of Science should feel it absolutely necessary to establish science talent searches. Scholarships should be granted by these groups to those excelling in academic attainments and having broad foundations. They should be based upon strict examinations of all applicants, and should not be limited to high school students. Different scholarships should be awarded to outstanding college and university seniors for use in furthering their scientific study in all types of scientific graduate schools.

In further conserving the scientific talent of our Texas youth a program might be instigated for the periodic investigation of the various academic institutions, colleges, universities, and high schools for the purpose of determining methods and quality of instruction in science at these institutions, as well as the effectiveness of the instruction in the scientific approach. Furthermore, records should be made of the students who show promise. By keeping these records it should be an easy matter to determine what students would be eligible for competition in the examinations for scholarships. Many students who might otherwise become discouraged for financial reasons or for other seemingly insurmountable obstacles might thus be encouraged to enter institutions of higher learning. It is highly desirable that an effort be made to insure excellent instruction for all students interested in continued study in any field of science. Oftentimes it becomes difficult for those who have not had proper instruction or opportunity for acquainting themselves with the various ramifications of a particular field to continue successfully in higher educational institutions.

Thus it behooves us as individuals possessing insight into the future, and as patriots having keen desire to insure the maintenance of scientific leadership in this country to take steps now providing for every possible means of aid and encouragement of today's exceptional students who will be tomorrow's outstanding scientists. As a slogan for this undertaking we might adopt this statement:

Mankind's preservation wrought through conservation.

A PHYSICAL METHOD TO EVALUATE BODY VOLUME SPECIFIC GRAVITY AND FAT CONCENTRATION OF ANIMALS IN VIVO

Harry C. Dyme
Foundation of Applied Research
San Antonio, Texas

Grateful acknowledgment is made to Mr. J. W. Rhoades for his aid in the building of the equipment and to Mr. J. D. Millar for his assistance in conducting chemical analyses.

In most cases, nutritive studies must be regarded as incomplete unless they include information on the composition of the animal body. Measuring growth or fattening in terms of live weight or by the determination of such characteristics as height, width, length and girth of an animal is at best an indirect method and furnishes only a rough approximation to the nutritive value of the animal body. However, a chemical analysis of the entire body is time-consuming, expensive and under certain experimental conditions it may be impossible. For that reason, many research workers are interested in abbreviated procedures or simplified methods that will make it possible to estimate body composition or certain factors thereof. Several methods of this nature have already been developed.

J. L. Lush (1926) found that the relation between the fat content of the entire live animal and the dressing percentage in steers was represented by a correlation of coefficient of + 0.84. Thus the percentage of fat in the entire live animal equals 1.782 times the dressing percentage minus 86.40. K. F. Warner, N. R. Ellis and P. E. Howe (1934) found that the percentage of fat in the edible portion of a hog carcass equals 5.57 plus 1.54 times the percentage of cutting fat and belly based on carcass weight. According to O. G. Hankins and N. R. Ellis (1934) the percentage of fat in the edible portion of the carcass equals 22.45 plus 0.691 times average thickness of back fat in millimeters. C. W. Greene (1919) and C. R. Moulton (1920) emphasized the value of studying the composition of animals on a fat-free (protoplasmic) basis. C. R. Moulton, P. F. Trowbridge and L. D. Haigh (1922) used this method to clarify the changes in the composition of cattle that occur with increasing age. C. R. Moulton (1923) also showed that the water content of mammals (on a fat-free basis) decreases rapidly from the early embryo through birth and on to a stage called *chemical maturity*. Thereafter it decreases but slightly with further advancing age. The protein and ash content (on a fat-free basis) showed just the reverse relationship, namely a marked increase in relative content until chemical maturity; thereafter, little or no change occurred. Apparently the amount of fat in an animal has no effect on the fat-free composition of the body. Fat (H. P. Armsby and C. R. Moulton, 1925) is relatively the most variable component of the animal body, the amount of fat varying with the age and, especially, with the condition of the animal.

Excluding meat from very lean animals, E. H. Callow (1946) was able to express the protein and water content in terms of fat-content by:

(a) % of protein in boneless meat = 20.7 — 0.207 x the percentage of fat.

(b) % of H_2O = 77 — 0.77 x the percentage of fat.

Apparently the chemical composition of the boneless meat varies in a remarkably regular manner with the degree of fatness. Working with agricultural animals, J. A. Murray (1922) found that the average composition of the whole body at any stage can be calculated when the live weight and percent of fat in the body are known. He discovered that the chemical composition is constant and is not affected by fatness; age affected the composition only to a limited extent.

H. F. Taylor (1922) found that the body specific gravity of fish diminishes proportionately to the fat present. The navigation of fish in salt water is more difficult in proportion to the amount of fat present; fresher water is better suited as a physical medium. Migration from salt to fresh water is very difficult until a certain amount of fat is accumulated. The diminishing specific gravity which results from increasing fatness probably has a strong influence upon the movements of fish.

A. L. Tester (1940) developed a specific gravity method for determining fatness in herring; hydrostatic weighing was utilizing to determine specific gravity. A. R. Behnke, B. G. Feen, and W. C. Welham (1942) evinced a special interest in the relationship between specific gravity and the fat content of the body. These authors considered the lean body-weight to represent the active mass of protoplasm. The presence of an indeterminate amount of excess adipose tissue renders difficult any precise computation; e.g., metabolic rate or dosage of drugs in terms of total body weight. According to their data, it was possible to utilize body specific gravity measurements to estimate fat content. They postulated that the analyzed results of various earlier investigators had eluded comparison because of an unknown quantity of air present in the lungs when the measurements were made. Specific gravity values were corrected for this factor by determining the residual air volume in the lungs. Provided such a correction was made, corporeal density could be accurately measured within 0.004 unit by the hydrostatic weighing method. Using the Behnke procedure with humans, W. J. Messinger and J. M. Steele (1949) were able to calculate body fat and water with considerable accuracy from body specific gravity. E. N. Rathbun, N. Pace, H. E. Hinshaw, and A. Buntin (1945) described a method to determine total body fat by comparing specific gravity, calculated from water displacement, with actual fat determinations by extraction. Specific gravity was determined on the eviscerated carcass of guinea pigs. Equations were derived for the calculation of percent fat in guinea pigs and also in man.

M. F. Morales, E. N. Rathbun, R. E. Smith and N. Pace (1945) treated the body as a multiple phase system of fat, bone, muscle, skin, nervous and visceral tissue, and developed equations which give the amount of each tissue component as a function of body weight and average body density. Their equations are based on the assumption that the lean body mass is relatively uniform in composition. Fat is regarded as the only component that exhibits appreciable relative variation. Quantitative data obtained with the guinea pigs substantiated the assumption.

N. Pace and E. N. Rathbun (1945) presented data supporting the concept of a lean body mass that is relatively constant in gross chemical composition. The nitrogen and water content was found to be constant on a fat-free basis; body fat acts merely as a diluent. N. Pace (1945) derived equations for the computation of total body fat and total body water from the equilibrium solubility values in the body of two inert gases. An equation was also derived for the computation of total body fat from the equilibrium solubility of one inert gas based on the assumption that water forms a constant percentage of the fat-free body mass.

B. T. Scheer, S. Dorst, J. F. Codie and D. F. Soule (1947) described a specific gravity method based on the determination of body volume by water displacement. They did not find a significant correlation between specific gravity and fat content of the animal body. Whereas some of the earlier investigators (A. R. Behnke, B. F. Feen and W. C. Welham (1942)) had applied a correction for the air in the lungs and others (E. N. Rathbun, N. Pace, H. E. Hinshaw and H. Buntin (1949)), by determining specific gravity on the eviscerated carcass, had eliminated variations caused by lung volume, body volume determined by the Scheer group includes lung volume.

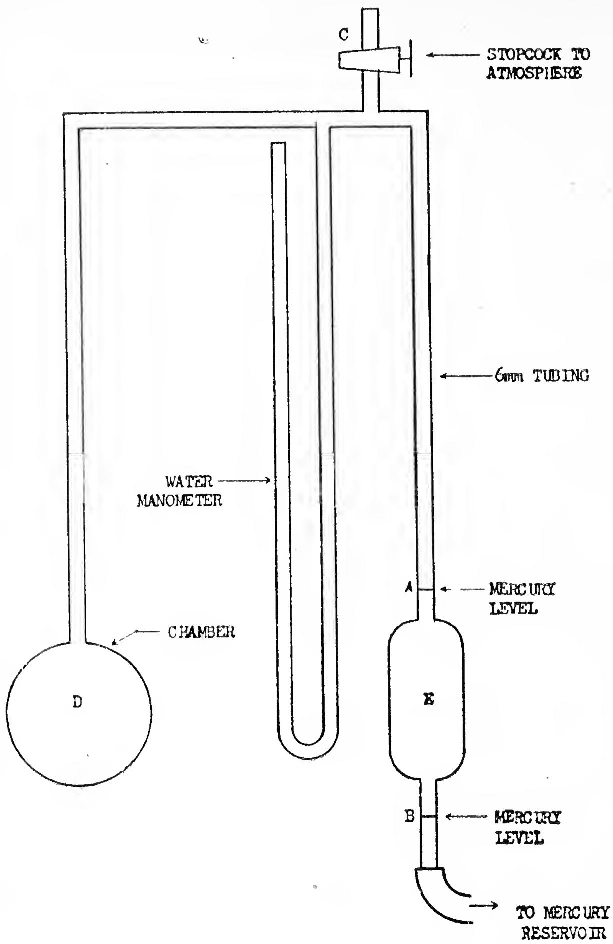
Calculations were undertaken to test the concept of constant composition in the fat-free body. The results are given in Table I. Water, protein, and ash concentrations (A, B, and D) of different beef cuts (A. L. Winton and K. B. Winton (1937)) were recalculated on a fat-free basis. This narrowed the range of concentration quite markedly (E, F, G) and grouped the values very close to their arithmetic means. Utilizing the arithmetic means of these fat-free values as the constants for water, protein, and ash, these components were recalculated on a whole-body basis (A_1, B_1, and D_1). The figures indicate that protein, water and ash concentrations of various portions of the animal may be readily evaluated merely by determining the fat concentration and then assuming a constant composition for the lean body mass. Therefore, these calculations greatly strengthen the concept that the composition of the fat-free mature animal body is constant.

Work was undertaken to develop a volumenometer which would measure body volume and body density (specific gravity) in the living animal. Since an animal can be weighed to within 0.1 gram, the accuracy of a specific gravity determination is principally limited by the accuracy of volume measurements.

If a manometer is properly attached to a closed system and the contained air is compressed by means of some levelling device, the rise of the manometer column is related to the quantity of air in the system. If a solid body is then introduced into the system the quantity of contained air becomes reduced which results in a greater rise in the manometer column upon subsequent compression. The volume of the body introduced into the system may be exactly determined by comparing the manometer readings obtained prior and during the body's presence in the system. This principle was utilized in building our first apparatus (Model I).

This apparatus consists of a stainless steel chamber (D) connected by glass tubing to a water manometer and a glass bulb (E). Lines are marked in the tube as A and B. The apparatus was calibrated with precision-volume steel blocks. An animal was placed in D and the air-tight end was closed.

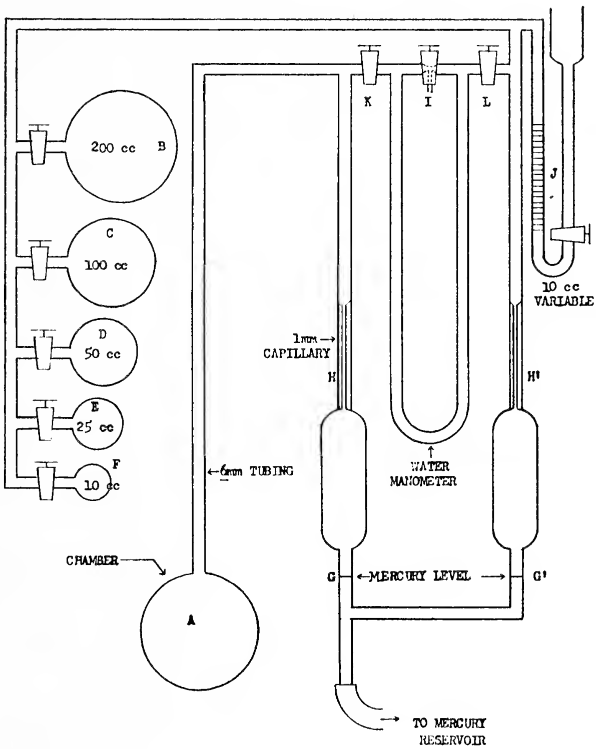
MODEL I



The mercury level was adjusted at B, the stopcock C which had been open to the atmosphere was closed, the mercury level was raised to A and the manometer reading was taken. Since compression is always accomplished by eliminating the same volume (B to A), the restulting pressure indicates the volume of the system from which it is possible to evaluate the volume of the body placed in the system. The shape of the calibration curve does not alter with atmospheric changes but its position does shift. The apparatus must, therefore, be calibrated each day it is used. Furthermore, the apparatus proved to be very sensitive to temperature changes; the manometer reading changed several centimeters when a hand was held in contact with the chamber wall. Since the temperature of a rat is several degrees above that of the room, we finally had to enclose the entire apparatus in a cabinet thermostatically controlled at the body temperature of the animal (38°C). The results were only accurate to within 2%; this is probably due to the low pressures involved (approx. 1.1 atmosphere). The heat of compression was responsible for an appreciable difference in the pressure reading; the readings could not be duplicated even though they were taken at the same time after compression. A two-minute waiting period appeared to be necessary before readings could be taken; however, leaving the rat in the system for such an interval did not prove feasible.

The next apparatus (Model II) that was built consists of essentially two complete systems of equal volume connected to each other by means of a water manometer. Compression, brought about by eliminating an equal

MODEL II



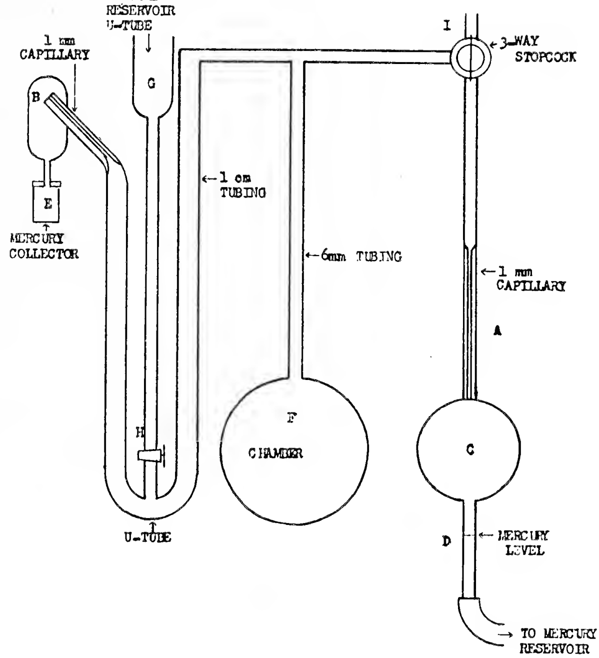
volume in each system through raising the mercury level (G',G to H,' H) in the closed apparatus (I closed), affects both systems to the same extent. One system contains a single chamber (A) fitted with an air-tight cover; the animal is placed in this chamber. The other system consists of several precision volume chambers (B, C, D, E, F) and an adjustable precision-volume J so that any desired volume may be accurately eliminated from the system. When the empty closed apparatus is compressed there is no difference in liquid level in the manometer for the final volumes of the two systems are still equal. A rat is placed into the chamber (A) and a volume approximately equal to that of the animal is eliminated from the other system. The two systems are then shut off from the atmosphere at (I) and compressed as in the previous operation. A pressure difference between the systems, (after compression) is the result of an initial volume difference (before compression). Zero difference in the liquid level indicates that the animal volume is exactly equal to the eliminated volume. To derive the rat volume when there is a pressure difference, the difference between the volume of the rat and the eliminated volume is calculated from the gas laws and applied to the known eliminated volume. Heat of compression effects cancel out because the volumes are equal in the empty systems and almost equal in the loaded systems. Although the actual pressures employed are 1.2 to 1.5 atmospheres, only a small water manometer is required, for the pressure difference is slight. Since the entire apparatus is contained in a cabinet thermostatically controlled at 38°C, operation is not affected by the body heat of the animal. Immediately after compression the manometer can be cut off from the rest of the apparatus at K and L. Respiratory air exchange has little effect on the determination because the operation is so rapid. Daily variations in atmospheric pressure do not affect the results, for measurement is on a comparative basis. The use of capillary tubes (1 mm.) H' and H instead of definite level marks accelerates the determination greatly. Error was found in the operation of this apparatus except where the two displaced volumes were virtually equal. By repeatedly altering the volue of the eliminated volume until the two were almost equal, volumes could be determined within 0.2 cc. However, since twenty seconds were required to equilibrate the apparatus after compression, repeated runs with rats did not prove practical. The presence of the animal in the chamber for this length of time so altered the reading that results could not be duplicated.

To overcome these difficulties a third apparatus was built which would record maximum pressure immediately after a very rapid compression. This apparatus (Model III) utilizes pressures ranging from 1.2-1.5 atmospheres. It consists of a single system that is very simple in design and principle. The water manometer has been replaced by a U tube (1 cm. diameter) containing mercury. This U tube is open to the atmosphere through a capillary tip B. The stopcock H is opened long enough to allow mercury to flow in from G until it begins to escape from B. The system is shut off from the atmosphere at I and then compressed by raising the mercury level from D to A; this forces mercury out at B into the collector E. The apparatus is calibrated with steel blocks of known volume. The system can be compressed very rapidly (less than 10 seconds) and only the maximum pressure is recorded. The results of determinations on metal blocks checked very closely with those determined by other methods. The error was less than $\pm$ 0.5 cc. and was generally as low as $\pm$ 0.3 cc.

Using this volumenometer in a constant temperature room (38°C) volume determinations were run on twelve rats and their specific gravities were calculated. The specific gravity values for animals of similar fat composition appeared to increase with the size of the animal; i.e., they were not strictly proportional to the percent of body fat. However, it is readily apparent that the larger animals are subjected to greater pressures in this apparatus than the smaller ones. Since the animal body contains trapped air spaces, an animal that is subjected to a higher pressure would be compressed to a greater degree; this greater relative compression would result in a smaller apparent volume and a larger specific gravity. This assumption would account for the results observed.

With this in mind the values were adjusted to a comparative basis (i.e., reduce the volumes of the larger animals to values which would have

MODEL III



been secured had they been measured under the same pressure) and the corrected volumes were used to calculate animal spcific gravity (Table II). The specific gravity values are plotted against fat concentration in Graph I. Using the arithmetic mean of the fat and specific gravity values a theoretical line was derived by adding uniform increments of fat (assumed specific gravity = 0.940) and calculating the resulting changes in fat concentration and specific gravity. All of the rats, except number 12, are clearly grouped about this theoretical line. This animal, according to the chemical maturity concept (C. R. Moulton (1923)), is immature; this would account for the large deviation since the fat-free body of the immature animal differs in composition from that of the mature animal.

DISCUSSION

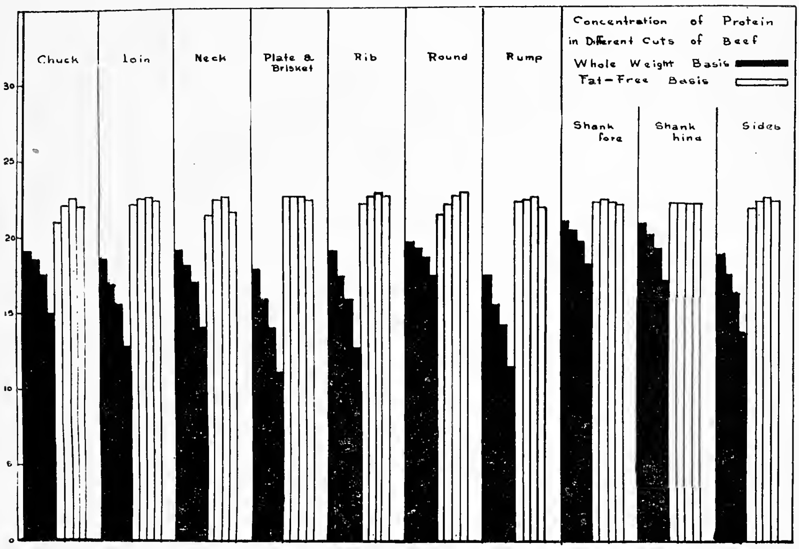
Gain in body protein and fat in conjunction with weight of feed consumed are generally employed to yield a measure of the feed utilization efficiency in storing productive energy; but it must be recognized that this value gives no indication of how the efficiency changed during the period the feed was being consumed. Thus, two animals may be equally efficient in their use of feed at one age but very unlike at some other age. In order to use a method which permits determination of (a) the initial efficiency, i.e., the efficiency when the first feed was eaten; (b) the rate at which the efficiency changed as the percent of various components change; and (c) the efficiency of any composition within the range for which data were obtained, it is necessary to have data on the body composition of the animals obtained at appropriate intervals, and the cumulative weights of feed consumed up to each time when body composition determinations are made.

Thus, a method to determine composition of gains in the live animal would make possible a better evaluation of rations and nutritive values of foods. At present the partial composition of gains in the live animal may be derived, after a fashion, by time-consuming and laborious nitrogen balance and respiration metabolism studies. Thus a convenient, facile and rapid method to derive animal body composition values should prove very useful, permitting many determinations to be made at frequent intervals. Such a method hinges upon the relation of specific gravity to fat content and utilizes the constant composition values of the fat-free body. Deriving the specific gravity of an animal by hydrostatic weighing presents serious practical difficulties and also fails to allow for the volume of air in the lungs and the intestinal tract. Similarly body density determinations involving body volumes obtained by water displacement erroneously include the volume of air in these sections of the body. In addition, air may be trapped in the fur of the animal. On the other hand, body volume determinations utilizing the corporeal volumenometer, which automatically takes lung and intestinal tract volume into account, most authentically represent the actual volumes occupied by the body substance of the animals. The specific gravity values calculated from the volumes thus determined represent true corporeal density. Since the content of carbohydrate in the body is quite small, an estimation of the continual changes in fat and protein content in the live animal yields an approximately complete picture of the influence of food upon the organic composition of the body.

SUMMARY

A corporeal volumenometer has been devised and built which measures the body volume of live animals. Animal volume is determined by record-

ing the difference in compressibility of the contained air with and without the animal. Body density or specific gravity is then calculated from the volume and weight of the animal. Since the fat content was found to be proportional to the animal's specific gravity, the former may be calculated from this value. In the light of evidence of the relative constancy of composition of the lean body mass protein, ash and water concentration may be readily calculated when the fat values are known. The possibility of employing this method to evaluate body composition in the living animal and its implictions are discussed..



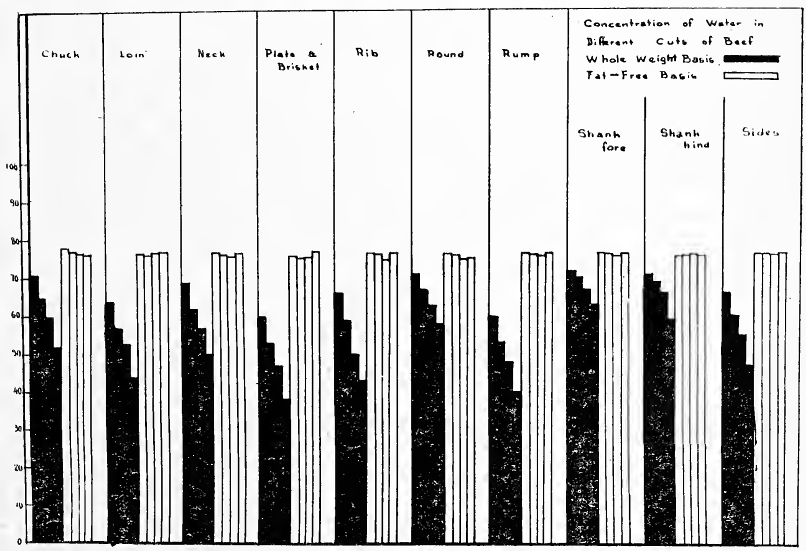


TABLE I

Composition of Various Beef Cuts Calculated on Different Bases

Cut	Class	As Purchased Bone	Visible Fat	Edible Portion: Chemical Composition in Percent: Water		Protein (N x 6.25)		Fat (ether extract)	Ash		% on Fat-Free Basis**: Water	Protein	Ash
		%	%	A*	A_1**	B*	B_1*	C*	D*	D_1**	E	F	G
Chuck	Thin	19	8	71	69.7	19.2	20.3	9	0.94	0.97	(78.02)	(21.09)	1.03
	Medium	17	13	65	64.3	18.6	18.7	16	0.88	0.90	77.38	22.14	1.04
	Fat	15	17	60	59.7	17.6	17.4	22	0.82	0.83	76.92	22.56	1.05
	Very Fat	13	24	52	52.1	15.0	15.2	32	0.74	0.73	76.47	22.05	1.09
Loin	Thin	16	15	64	64.3	18.6	18.7	16	0.95	0.89	76.19	22.15	1.13
	Medium	14	24	57	57.4	16.9	16.7	25	0.84	0.80	76.00	22.53	1.12
	Fat	12	30	53	52.9	15.6	15.4	31	0.77	0.73	76.81	22.60	1.11
	Very Fat	10	41	44	43.7	12.8	12.7	43	0.62	0.61	77.19	22.45	1.09
Neck	Thin	27	12	69	68.2	19.1	19.8	11	0.92	0.95	77.52	21.46	1.03
	Medium	26	17	62	62.0	18.2	18.1	19	0.85	0.87	76.54	22.47	1.05
	Fat	25	22	57	57.4	17.0	16.7	25	0.80	0.80	76.00	22.66	1.07
	Very Fat	24	29	50	49.8	14.0	14.4	35	0.71	0.70	76.92	21.54	1.09
Plate & Brisket	Thin	22	17	60	60.5	17.9	17.4	21	0.87	0.85	75.95	22.65	1.10
	Medium	18	27	53	53.6	15.8	15.6	30	0.75	0.75	75.71	22.57	1.07
	Fat	15	34	47	47.5	14.0	13.8	38	0.65	0.66	75.81	22.58	1.05
	Very Fat	11	47	(38)	(37.5)	(11.0)	(10.9)	(51)	(0.48)	(0.52)	77.55	22.44	(0.98)
Rib	Thin	25	8	66	65.8	19.0	19.1	14	0.94	0.92	76.74	22.09	1.09
	Medium	21	18	59	58.9	17.4	17.2	23	0.83	0.82	76.62	22.50	1.08
	Fat	18	24	52	52.8	15.8	15.4	31	0.74	0.74	(75.36)	(22.90)	1.07
	Very Fat	14	38	43	42.9	12.7	12.5	44	0.59	0.60	76.78	22.68	1.05

Round	Thin	12	8	71	70.5	19.7	20.5	8	(1.00)	0.98	77.17	21.41	1.08
	Medium	11	13	67	66.6	19.3	19.4	13	0.95	0.93	77.01	22.18	1.09
	Fat	10	16	63	63.5	18.7	18.5	17	0.90	0.89	75.90	22.53	1.08
	Very Fat	9	22	58	58.2	17.4	16.9	24	0.82	0.81	76.32	22.89	1.07
Rump	Thin	27	25	60	59.7	17.4	17.4	22	0.88	0.83	76.92	22.31	(1.13)
	Medium	24	33	53	52.9	15.5	15.4	31	0.77	0.74	76.81	22.46	1.11
	Fat	22	39	48	48.3	14.2	14.0	37	0.69	0.67	76.19	22.53	1.09
	Very Fat	19	50	40	39.8	11.4	11.6	48	0.56	0.56	76.92	21.92	1.08
Shank, Fore	Thin	41	7	(72)	(72.0)	(21.0)	(21.0)	(6)	0.98	(1.01)	76.60	22.34	1.04
	Medium	41	10	70	69.7	20.4	20.2	9	0.94	0.97	76.92	22.42	1.03
	Fat	40	12	67	67.4	19.7	19.6	12	0.90	0.94	76.14	22.38	1.02
	Very Fat	38	18	63	62.8	18.2	18.2	18	0.83	0.88	76.83	22.19	1.01
Shank, Hind	Thin	59	8	71	71.2	20.8	20.7	7	0.96	1.00	76.34	22.36	1.03
	Medium	59	12	69	68.9	20.1	20.1	10	0.93	0.96	76.66	22.33	1.03
	Fat	57	17	66	65.8	19.2	19.2	14	0.88	0.92	76.74	22.33	1.02
	Very Fat	55	26	59	59.0	17.1	17.2	23	0.76	0.82	76.62	22.2[illegible]	0.99
Sides	Thin	19	14	66	65.8	18.8	19.1	14	0.97	0.92	76.74	21.86	1.12
	Medium	16	21	60	59.7	17.5	17.4	22	0.87	0.83	76.92	22.43	1.12
	Fat	15	27	55	55.2	16.3	16.1	28	0.79	0.77	76.38	22.64	1.10
	Very Fat	12	38	47	46.7	13.7	13.6	39	0.65	0.65	77.04	22.46	1.07
	Arithmetic Mean —			58.7	58.6	17.1	17.1	23.5	0.82	0.82	76.6	22.3	1.07

* Values from p. 327, Structure and Composition of Foods, Vol. 111. Winton and Winton.

** Calculated values; A_1, B_1 and D_1 were calculated from the following equations:

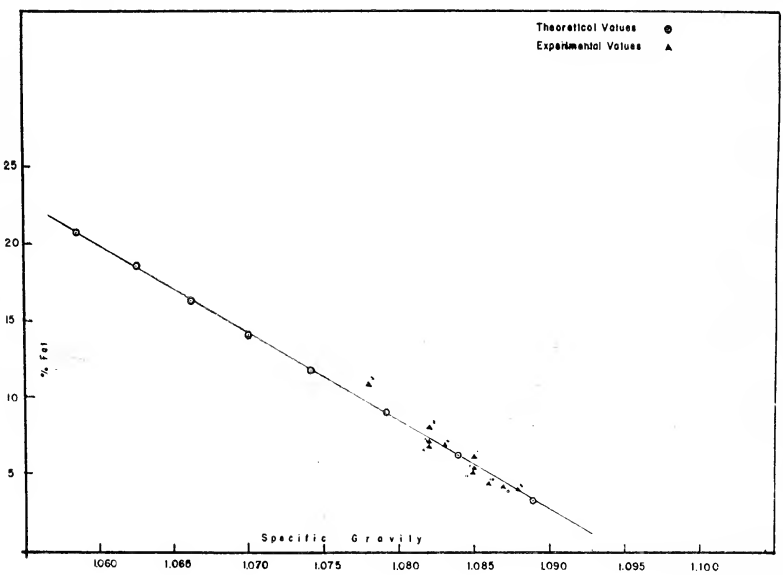
$$A_1 = \frac{100 - C}{100} \times 76.6 \qquad B_1 = \frac{100 - C}{100} \times 22.3 \qquad D_1 = \frac{100 - C}{100} \times 1.07$$

( ) Highest and lowest values are enclosed in parentheses.

TABLE II

BODY VOLUME, SPECIFIC GRAVITY AND FAT CONTENT OF RATS

NO.	SEX	WEIGHT grams	VOLUME c.c.	SPECIFIC GRAVITY	FAT %
1	F	216.9	199.9	1.085	6.2
2	F	197.0	182.1	1.082	8.1
3	M	202.9	187.5	1.082	7.2
4	M	222.6	205.5	1.082	6.9
5	F	164.9	153.0	1.078	10.9
6	F	188.7	174.2	1.083	7.0
7	F	130.2	120.0	1.085	5.5
8	M	107.3	98.6	1.087	4.3
9	F	135.2	124.2	1.088	4.0
10	M	171.0	157.5	1.086	4.5
11	M	136.8	125.1	1.085	5.2
12	M	105.5	97.1	1.087	2.3



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COASTAL DRAINAGE PROBLEMS IN RELATION TO WATERFOWL

John R. Singleton
Texas Game, Fish and Oyster Commission
Rockport, Texas

The constant supply of fresh water plays a major role in the management of waterfowl marshes and feeding areas. This has been vividly demonstrated not only this year, but in previous years as well. Local conditions may vary greatly as was the case this fall.* The lower portion of the coast from Freeport to Brownsville had plentiful rains in August, September, and some rain in October. The ponds, potholes, and low areas were filled with fresh water after a dry summer. So much so in fact that most waterfowl food plants began a rapid second growth and produced a second crop of fruits. Looking over this area, one might conclude that, for once, waterfowl conditions were excellent, with plenty of watered potholes and ponds and a plentiful supply of natural foods. This, however, did not hold true for the entire coast. In that region northeast of Freeport, the marshes were extremely dry. Water was scarce and in many instances the available water was brackish due to tidal action and through the normal process of evaporation. In this particular section on the coast, available water was limited to flooded rice fields, rice canals, reservoirs and a few large ponds.

In order to relate this problem of available water to present drainage programs, I would first like to give a few facts and figures on drainage plans in that region of the coast from Galveston Bay to Sabine Lake, embracing the counties or Jefferson, Chambers, and Liberty. The purpose of these drainage programs is to improve the land for its best land-use practices by being in a position to control water and soil erosion.

* 1948

There are three drainage districts involved in these counties:

1. The lower Trinity District of 654,000 acres in Chambers County west of the Trinity River, and all of Liberty County except the southeast corner. Organized in June, 1945.
2. The Trinity Bay District of 437,200 acres in Chambers County east of the Trinity River and Trinity Bay, 81,000 in the southwest corner of Liberty County, a total of approximately 582,200 acres. Organized in April, 1943.
3. The Coastal District of 523,800 acres, being all of Jefferson County except the 81,000 in the southwest corner included in the Trinity Bay District. Organized in January, 1943.

The benefits to be derived from these drainage programs are as follows:

1. The ultimate improvement of economic and social standards of the people through conserving and developing the soil and water resources.
2. The setting up of a program whereby all landowners within a district may work together in solving drainage, erosion, and related problems.

Immediate benefits would be in the form of additional acreage available for crop production such as rice and sorghum, increased crop yields through drainage improvements, and improved highway and county road drainage.

In a recent conversation with Robert A. Harling, District Conservationist, Soil Conservation Service, Liberty, Texas, I was informed that no plans have been made, nor were anticipated, to drain any of the marsh land within these counties, since the best land practice use on such areas would be wildlife and grazing. Therefore, the plans are to drain those areas above the marsh and to provide a system of waterways to carry the waters through to the bays or its natural deposition point. There is one outstanding instance where this was done partially with very harmful results. Spindletop Gully, in Jefferson and Chambers Counties, which drains 60,000 acres, was dredged out to the edge of the marsh. The bottom was widened from 12 to 50 feet. The results was that during seasons of heavy rainfall, this water hits the marsh with a three foot head on it. With no system having been provided to carry this excess water through and out of the marsh, it has flooded the area with disastrous results. The marsh previou to drainage had been an excellent muskrat and waterfowl habitat, with considerable grazing acreage available, even though brackish. Now it has 3 to 5 feet of water on it during the rainy season and is a fresh water marsh, with large stands of fresh water reed cane making it virtually useless for wildlife or cattle. An additional factor in this particular case is the Intracoastal Waterway. Army Engineers are adverse to emptying these drainage ditches into the canal because a rapid flow of water interfers with the normal handling of tugs and barges. The only way to take this excess water out of the marsh above or north of the canal is to either divert the natural flow of water, which meets strenuous objections from the landowners, or to cut a ditch parallel to the canal and to the nearest lake or bay.

While the overall drainage program does not include drainage of the marsh itself, portions of the marsh are being drained. In order to carry the excess water through the marsh, it has been necessary to dredge some of the old bayous out to a depth of 16 feet, and a surface width of 100 feet or over. Exact figures on these measurements were not available. It is not difficult to see what this has done. To be specific, Hilderbrant's Bayou in Jefferson County, which drains the city of Beaumont, has been dredged to approximately the dimensions given above. During the dry summer months of 1948, we were in this bayou and adjacent marsh. In places which normally held some water the year around, there was nothing but dry earth and 2 to 4 inch cracks in the marsh bottom. The deepening of the bayou had drained all water from the slow moving sluggish tributary streams and left them high and dry.

Likewise, during the dry season when water from rice irrigation was at a premium, the marsh streams were at such a low level that salt water from the Gulf intruded for a distance of twenty or thirty miles in these streams.

In the foregoing it may appear that I have a very low opinion of the drainage work. I certainly have not intended to leave that impression. While some detrimental effects have been observed under present conditions, we would be foolish to take the stand that all drainage is bad. It can not be denied that once these plans are completed, the upland landowners will be greatly benefited. Our problem, as I see it, is to work out some system of cooperation to make use of this water being carried through the marsh. Mr. Harling is indeed a very cooperative person and has requested that we show our side of the problem to him and give our recommendations for a cooperative program.

The problem now is—what can we do? Is it possible to store this water for future use? Can some system be devised to hold water on the marsh which will naturally be drained by the 3 or 4 outlets to be put through the marshes? These problems must be worked out. At present I do not know the answers. However, we are fortunate that most of these plans are only on paper.

We have at least two years before these plans can possibly be in operation. Some drainage is being done at present, but it is by town, or highway, or rice irrigation canal companies. The plans of the S. C. S. cannot be in action in less than two years.

It seems to me that levees could be constructed along certain main drainage canals, with flood gates or locks on the tributary streams, to retain some water in the marsh; that additional salt water locks could be placed into operation to hold salt water out and fresh water in, and possibly that large reservoirs could be established to store water. Such a program will entail considerable expense, but if we want to preserve our wildlife it may be the only means.

Marsh landowners are going to suffer economic loss as a result of upstream drainage. Those who benefit from drainage should be planning to build the necessary structures to prevent flooding or drainage of the marshes. Since the cost of protective structures will be great and the marshes are on private land, the most practical solution seems to be for marsh owners to force drainage districts to protect them from loss.

In one way, waterfowl probably have benefited from drainage. It is interesting to note that domestic rice makes up from 40% (Chambers County) to 65% (Eagle Lake) of the total volumetric percentage of all food items eaten by waterfowl. These figures are from stomach analysis made during the previous two hunting seasons. Martin and Uhler in their bulletin on "Food of Game Ducks in the United States and Canada" show that rice makes up only 3.60% of the total volumetric percentage of foods eaten. However, their records date back to 1901 and include only 315 waterfowl from the Texas coast. Rice acreage has increased several times in Texas. The Texas Year Book states that approximately 145,000 acres were in rice in 1896. According to the 1948 Texas Almanac 412,000 acres of rice were harvested in 1946. It is very likely that a great deal of this increased acreage was in areas of excellent natural waterfowl habitat.

In order to maintain the waterfowl marshes on the Texas Coast, it is essential that water levels be constant. This is necessary for growth of marsh habitat of waterfowl and muskrats, as well as for insuring breeding success of the native mottled mallard and muskrats.

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THE NORTH AMERICAN SPECIES OF MACROBRACHIUM (River Shrimp)

Joel W. Hedgpeth
University of Texas
Institute of Marine Science
Port Aransas, Texas

INTRODUCTION

The large river shrimps occurring in the United States are well known locally, because of their size and huge claws, and one species is of some commercial value. Nevertheless, the literature on these interesting crustaceans is so incomplete and scattered that identification of the various species by non-specialists has been impossible. The river shrimps are members of the palaemonid genus *Macrobrachium,* closely related to the little freshwater grass or "glass" shrimps of the genus *Palaemonetes.* There are several other genera in the family Palaemonidae, including *Palaemon* and *Leander,* but these usually occur only in the sea. Some of the species are found characteristically among the creatures which comprise the microcosomes of the sargassum. Recently, Dr. L. B. Holthuis of the Rijksmuseum van Natuurlijke Historie of Leiden, working at the U. S. National Museum, made a thorough systematic revision of the American members of the Palaemonidae. This work is now awaiting publication by the Allan Hancock Foundation, and I am indebted to Dr. Holthuis for much of the information on the taxonomy and systematics of the genus *Macrobrachium,* and for the details on which the key to the species north of the Rio Grande is based. Since Dr. Holthuis' comprehensive work is a purely systematic treatment, this paper will summarize what is known of the ecology and distribution of this genus in the waters north of the Rio Grande.

The literature on river shrimps in the United States is surprisingly meager, and several of the species remained unfigured before the author's note in the Progressive Fish-Culturist (1947). Disregarding the casual systematic and distributional notes on the various species, there are but four important papers on the Macrobrachiums of the United States. The first of these is Schmitt's (1933) distributional notes on all four species. This was followed by McCormick's papers (1933, 1934) on the anatomy of *Macrobrachium ohione*. A few years later, Gunter (1937) published the results of a preliminary study of the life history of the same species.

Genus MACROBRACHIUM Bate

The generic name *Palaenon* is common in earlier literature, including Ward and Whipple (1918, p. 845). Another name formerly used for this genus is *Bithynus*, which was favored by Rathbun (1902) More than a hundred species of *Macrobrachium* are recognized, occurring throughout the tropical regions. Twenty-six species are known from the Western Hemisphere, but only four have been recorded north of the Rio Grande. On the whole, the species are partly euryhalin, but there is no entirely marine species although the adults of many species invade bays, and the larvae of some Indo-Pacific species have been found in the sea. Without doubt this occurrence in bays accounts for the widespread distribution of many species, which have been able to spread through many river systems from bay to bay (Gunter, 1937), or through the dispersal of their larvae, which may be more tolerant of higher salinities than the adults. It is possible, especially on the Gulf Coast, for strictly freshwater organisms to migrate from river to river via stream confluences at the deltas since late Pleistocene time (Price, 1942). Some species are exclusively fresh water in habit. It is of interest to note that while many marine animals, including such decapod Crustacea as the blue crab, *Callinectes sapidus,* frequently invade freshwater, very few fresh water organisms, once established in this environment and spawning therein, return to the sea. Exceptions of course are the anadromous fish such as salmon and sturgeon. The gizzard shad, *Dorosoma cepedianum* (Le Sueur) of the eastern and middle United States is a partially anadromous species (Gunter, 1945) with completely landlocked populations and others which invade brackish waters, behaving in this respect like some populations of *Macrobrachium*.

The principal characters of the genus *Macrobrachium* are as follows: the carapace bears a prominent rostrum, and has two spines, the antennal spine on the anterior margin below the orbit, and the hepatic spine, obliquely below the antennal spine, well behind the anterior margin of the carapace. There is a short, well developed branchiostegal groove from the anterior margin of the carapace to the hepatic spine. There are two pairs of spines on the dorsal surface of the telson and two pairs on the posterior margin. The mandible bears a three jointed palp. The eyes are well developed, with a black cornea. The first two pairs of legs are chelate, and the second chelipeds are usually large in the adult (hence the generic name *Macrobrachium)*, and spiny. The last three pairs of legs are simple.

The species found in the United States may be determined according to the following key:

1. Carpus (i.e., "wrist" jt.) of second chelipeds as long as, or longer than, the merus (preceding jt.) 2
Carpus of the second leg or cheliped distinctly shorter than merus, right and left chelipeds subequal. Both fingers provided with a single large triangular tooth. Rostrum arched over eye, tip directed upwards, four to six teeth dorsally behind orbit .... *carcinus*
2. Chelipeds similar, subequal, with straight fingers; rostrum somewhat arched, two to four teeth dorsally behind orbit 3
Chelipeds dissimilar, larger one heavier, with inflated palm, fingers of smaller chela arched, gaping; rostrum comparatively straight, with 12-15 small teeth dorsally, 4-5 behind the orbit .... *olfersii*
3. Dorsal teeth of rostrum continued out to tip, two behind orbit, ventral teeth more or less regularly spaced along rostrum; chelipeds large, strong, fingers covered by velvet or felt-like pubescence, with single large proximal tooth and small denticles behind .... *acanthurus*
Distal tip of rostrum without spines dorsally and ventrally, 3-4 teeth dorsally behind orbit; chelipeds small, fingers naked or with scattered tufts of setae, with small, equal teeth proximally .... *ohione*

MACROBRACHIUM ACANTHURUS (Wiegmann)

This species is readily separable from the others by the long slender, cylindrical carpus and chela, and the presence of but two teeth on the

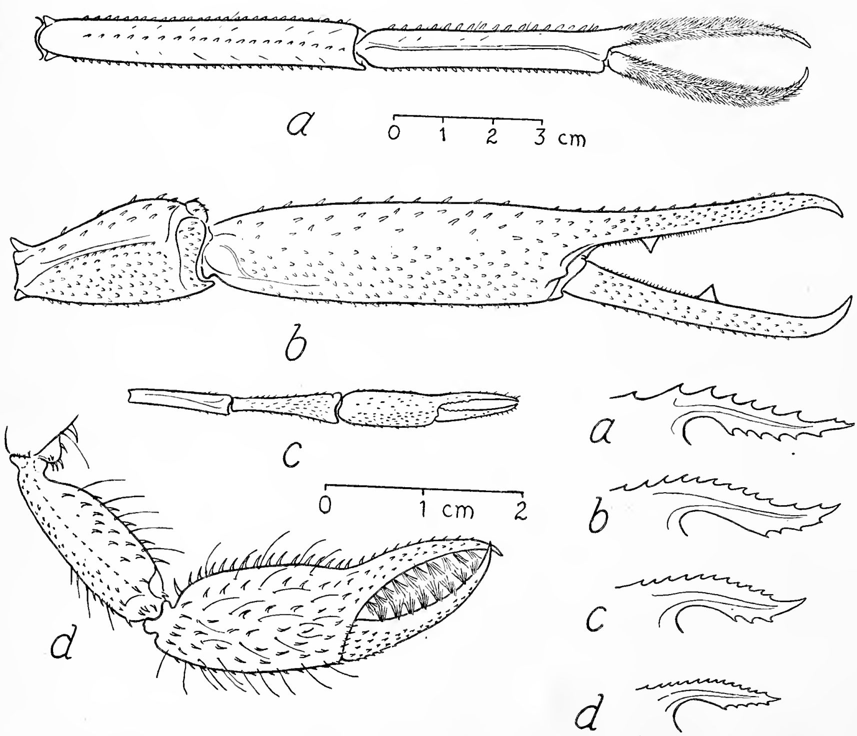


Figure 1. Chela and rostrum of a, *Macrobrachium acanthrurus;* b, *M. carcinus;* c, *M. ohione;* d, *M. olfersii.*

rostrum behind the orbit. The fingers are covered with a felt-like growth of fine setae, which are usually covered with mud. In life, this species is a generally olive green color, shading to blue on the edges of the abdominal pleura and the uropods. There is a broad, brownish orange stripe along the median dorsal surface of the abdomen. Specimens measuring 120 to 150 mm. from tip of rostrum to tip of telson are commonly found, and the chelipeds are about half again as long, i.e., 180-225 mm. An adult male is thus about fifteen inches in total length from telson to tip of the extended cheliped. The largest male in the U. S. National Museum collection measures 166 mm. from rostrum to telson. The females are somewhat smaller, and ovigerous specimens ranging from 36 to 110 mm. have been noted.

The range of this species is from St. Simon Sound, Georgia, to Rio Grande do Sul, Brazil, and the West Indies. It is found in Florida from St. Augustine to Coconut Grove, in Mississippi at Ocean Springs and Biloxi, in Louisiana at Lockport and near Grand Isle, and occurs in Texas along the coast in the bays from Palacios to the Rio Grande, and as far as Sioux Plantation, 97 miles up the Rio Grande.

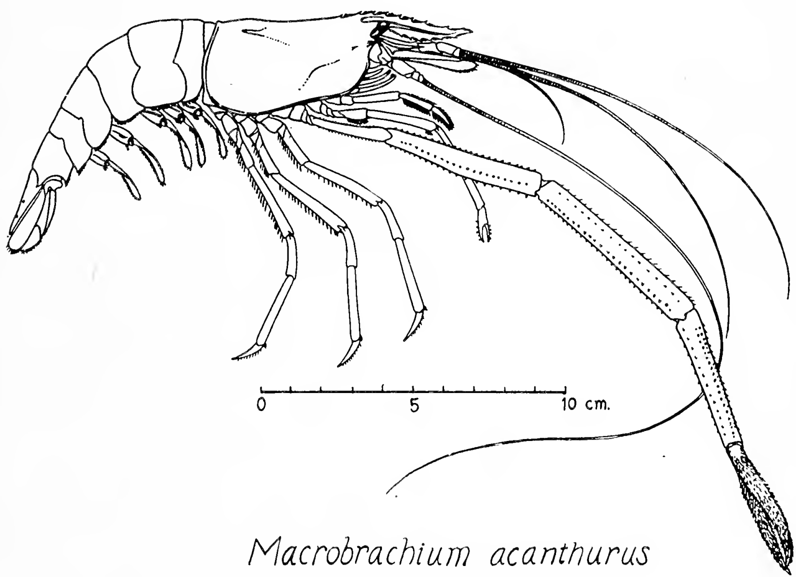


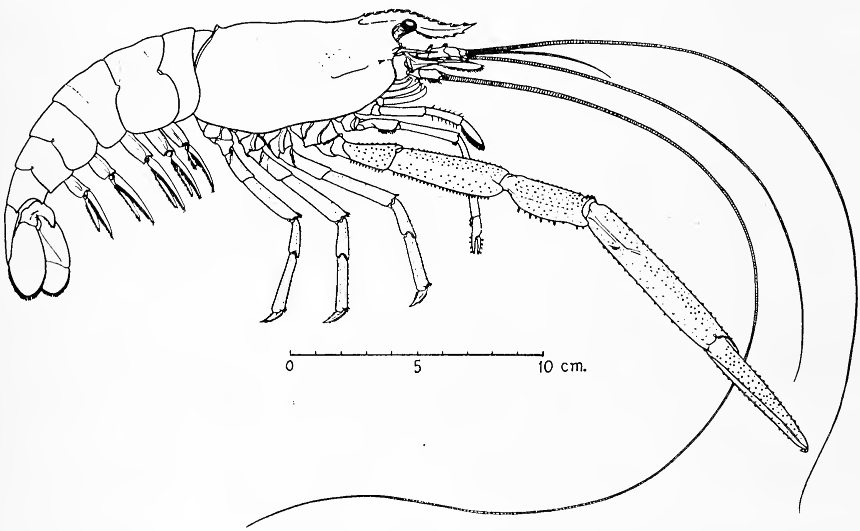
Figure 2. Lateral view of M. *acanthurus,* two fifths natural size.

After the heavy rains of September, 1946, this shrimp appeared in freshwater ponds around Rockport, Aransas County, in some numbers, evidently from the Aransas River drainage. There are several specimens in the collection of the Game, Fish and Oyster Commission at Rockport, most of them brought in by fishermen from the local bays. One ovigerous female was taken from Aransas Bay on September 10, 1935, another on Oct. 1, 1946.

MACROBRACHIUM CARCINUS (Linnaeus)

According to Dr. Holthuis, the name *Macrobrachium jamaicense,* by which this species was formerly known, should be abandoned in favor of the Linnaean name.

This is the largest and most spectacular species found in North America, and the most easily recognized, since the carpus of the cheliped is always short regardless of the age of the animal. In life it is a handsome creature. The general dorsal color is dark brown with rich opaque cream mottling on the sides, shading into a light olive green on the edges of the pleura and the legs. The large chelipeds are greenish, with brown-black tubercles and pale orange articulations. The outer uropods are dark, almost black-green, the inner are opaque cream. The telson is dark green but not as dark as the outer uropods. The largest measured specimen, a male, is 233 mm. from rostrum to telson. The second cheliped is not as long in proportion to the body as in M. *acanthurus,* and is but slightly longer than the body. It is much heavier than in the preceding species, however, and the large triangular teeth of the fingers are conspicuous.



Macrobrachium carcinus

Figure 3. Lateral view of M. *carcinus,* about three tenths natural size.

Because of its spectacular size, this crustacean is usually saved when caught, and specimens can be found in almost every town on the Texas coast, crammed into a two quart or gallon jar, displayed in restaurants and sporting goods stores. The range of this species is from St. Augustine, Florida, to Santa Catharina, Brazil, and the West Indies. It is found in several places in Florida, from St. Augustine to Miami and Big Pine Key, and in Texas from Matagorda Bay to the Rio Grande, but it has not been recorded from intervening localities. It is often taken in Texas rivers at considerable distances from the bays, and there are records from the Colorado River near Austin, San Marcos River near San Marcos, San Antonio, the Nueces River (it seems to be common in Lake Corpus Christi near Mathis, the water supply reservoir for Corpus Christi), the Rio Grande at Brownsville, and Devils River, Valverde County.

A specimen taken alive in Aransas Bay on October 10, 1946, was kept alive in an aquarium for two days. It appeared to be an alert and intelligent creature. When poked at with a pencil, it would reach beyond the pencil for the hand that held it, a somewhat disconcerting maneuver. The long chelipeds of these shrimp enable them to reach anywhere about themselves, and they are difficult to pick up alive without tongs or forceps. Several specimens of *Macrobrachium carcinus* taken from bay waters were observed to have small barnacles on the carapace. These appear to be young specimens of *Chelonibia patula* (Ranzani), a species often found on crabs and on the Diamond Back Terrapin.

MACROBRACHIUM OHIONE (Smith)

The shape of the tip of the rostrum, prolonged to a dagger like point, separates this species from the other three found in the United States. It is also the only species of the four in which the females are larger than the males. The second chelipeds are comparatively small in comparison with those of the other species. They are about as long as the body and rather slender. In the adult the fingers of the chelae bear a few small teeth or spinules on the proximal half. The general color is pale gray flecked with small blue spots; the uropods are pale blue. Females of this species occasionally attain a size of 100 mm. (102 being the largest known), and ovigerous specimens ranging from 34-90 mm. have been observed (McCormick). The largest male noted by Gunter (1937) was 68 mm.

This species is the only endemic member of the genus in North America, and is found from Avoca, North Carolina, to Aransas Bay, Texas, and has been recorded from the following localities:

North Carolina—Avoca, Bertie Co., Newport River, Carteret Co.
South Carolina—Cooper River; Edisto River below Dawho River.
Georgia—Savanah, Chatham Co., entrance to Altamasha River, Satilla River, Umbrella Creek.
Albama—Pinto Island, Mobile Bay, early May, 1929. (Fide M. D. Burkenroad).
Mississippi—Greenville, Washington Co., Milliken's Bend and Vicksburg, Warren Co., Pascagoula, Jackson Co., Baldwin Lodge, Hancock Co.
Arkansas—Fort Smith, Sebastian Co., Red River.
Louisiana—Delta, Madison Parish, Lake Ponchartrain, New Orleans and Grand Isle, Jefferson Parish, Pilottown, Plaquemines Parish, Bayou St. Denis, Barataria Bay, Lake Salvador, St. Charles Parish, Lake Lapourde near Morgan City, Atchafalaya River at Morgan City, St. Mary Parish, Calcasieu Pass, Calcasieu Parish, Port Allen, West Baton Rouge Parish.
Ohio—Ohio River at mouth of Great Miami R., S. W. Hamilton Co., mouth of White Oak Creek, Brown Co., Scioto River, Scioto Co., Perry Tp., Lawrence Co., White River below mouth of Mishingum River, Washington Co. (All Ohio records supplied by Mr. Milton B. Trautman, who reports that this shrimp is taken abundantly in S. W. Ohio only in the spring.)
Illinois—Cairo, Grand Tower, Chester, Shawneetown, lower Kaskaskia River (Luce, 1933).
Missouri—St. Louis, Hillcrest, Jefferson Co.
Indiana—Cannelton, Lawrenceburgh.
Oklahoma—Clear Lake, McCurtain Co.
Texas—Trinity River near Magnolia Point, Long Lake near Palestine, Big White Oak Bayou near Houston, Colorado River near Austin, Onion Creek 10 mi. west of Austin, Lavaca River, Mesquite Bay, Copano Bay, Aransas Bay as far south as Harbor Island.

This shrimp is especially widespread and common in southern Louisiana, where it is of undetermined importance as an item of food. Inasmuch as it is sold by individuals from door to door and directly to retail markets, there is no information available on the numbers caught or as to seasonal variations in the population. McCormick (1934) reported a small fishery for this species at Chester, Illinois, but that fishery seems to have been abandoned in recent years and the Illinois Natural History Survey has no information on its present commercial use in that state. Gunter (1937) suggested that the fishery in Louisiana amounted to several thousand pounds a year at that time. According to the Report of the Louisiana Conservation Commission for 1914-16, which incidentally contains what is evidently the first published photograph of *Macrobrachium ohione*, the annual value of this fishery was then $150,000. Luce (1933) reports its use as fish bait in the Kaskaskia River, Illinois.

In Louisiana the fishery is carried on during the summer months. Traps constructed of slats, similar to lobster pots (which have the advantage of allowing the young to escape), are the usual gear employed for catching the shrimp. They are baited with raw meat, fish or cottonseed

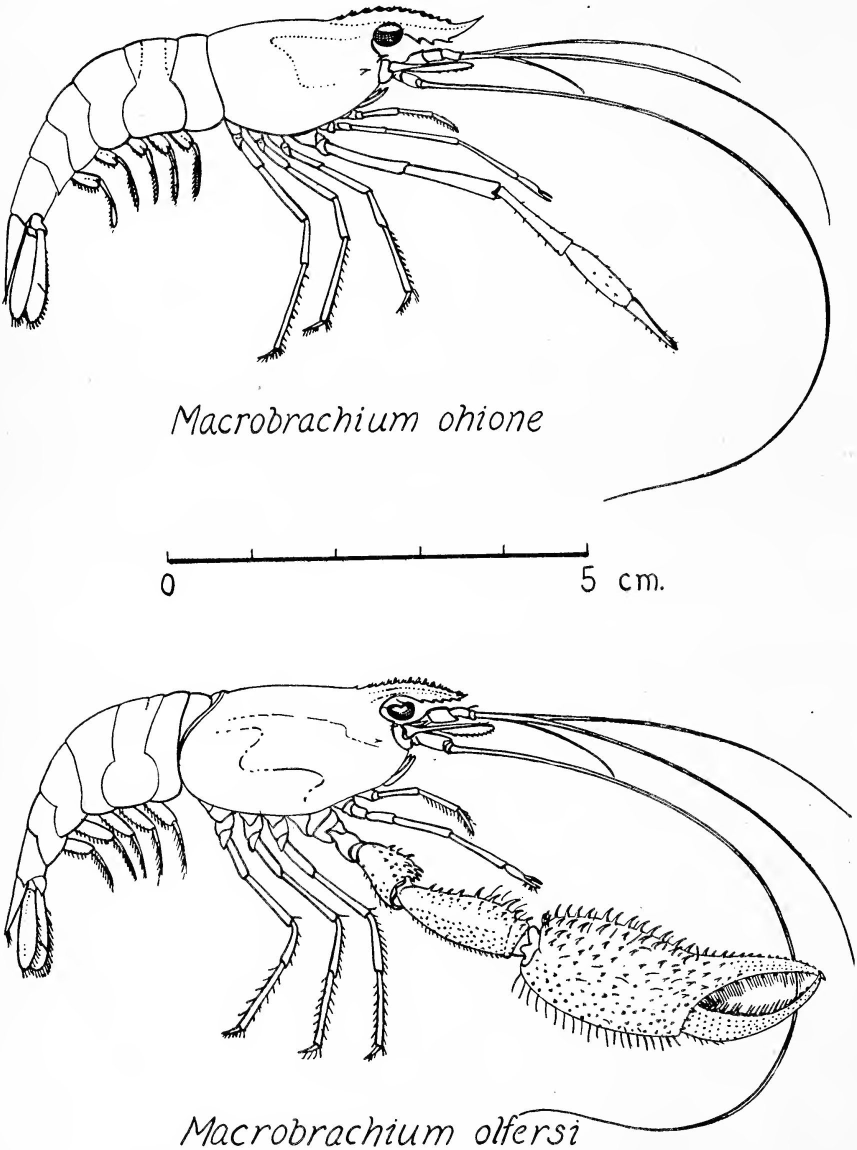


Figure 4. Lateral views of *M. ohione* and *M. olfersii*, about one half natural size.

cake. Cottonseed cake is sometimes placed in holding cages after the shrimp are caught to convince possible customers that more repulsive bait has not been used. In Illinois, the shrimp were caught by "sets" of green willow and cottonwood branches stuck into the mud near the river bank and broken over. In the lower river the young are found in shallow water, and the traps are set in deeper water in Louisiana. Individuals are often caught with pole and line by fishermen.

According to Gunter's notes (1937) on this species, the spawning season in the lower Mississippi area occurs from about April to July. Ovigerous females were taken from April 14 to July. It appears that a fairly large percentage of females do not bear eggs during the breeding season. The shrimp were found in bay water ranging from 1.38 to 14.24 0/00, without apparent effect on the development of the eggs. There is some indication that this species reacts unfavorably to high turbidity. If high turbidity during flood periods interferes with respiration of these shrimp it may explain their frequent appearance in bays during such seasons of the year.

MACROBRACHIUM OLFERSII (Wiegmann)

Unlike the foregoing species, the chelae of the second chelipeds of this species are unequal in size. Regenerated chelae are smaller but of the same shape as the originals. The larger chela is broad, rather flat, with well bowed fingers, and the outer surface of the palm is adorned with numerous fish-hook like spines which are directed forward. The narrow, finely toothed rostrum is a distinctive character. This is a small species: males measure up to 90 mm. and ovigerous females from 30 to 65 mm.

This species ranges from Florida, through Central and South America from Vera Cruz, Mexico to Santa Catharina, Brazil. In the United States it is found only at Davenport Park, Alcazar Pool and Old Waterwork Pool, St. Augustine, Florida. Obviously its occurrence in Florida is far outside its normal range, and it is somewhat of a mystery. Schmitt (1933) suggested that it may have been introduced accidentally. Oddly enough, two other species, *M. acanthurus* and *M. carcinus*, are also found in the Alcazar Pool.

GENERAL COMMENTS

As Ortmann (1902) pointed out more than forty years ago, *Macrobrachium* is probably a very recent genus which is in the act of immigrating into fresh water, and has yet to complete the process. It would appear, to judge from its widespread distribution in the lower and middle Mississippi drainage, that *M. ohione* is the oldest species of the four in North America, and that *M. carcinus* and *M. acanthurus* are of about equal age. Because of its widespread occurrence in Texas rivers, *M. carcinus* is evidently less dependent on salt water to complete its breeding cycle than *M. acanthurus*. A curious anomaly in the known distribution of *M. carcinus* is its absence from the Mississippi River and the area between Florida and Louisiana. This may be due primarily to inadequate records, but it is possible that the species may not be able to compete with *M. ohione* in the heart of the latter's range. The two large species, *M. carcinus* and *M. acanthurus*, overlap on the Texas coast and do not appear to be strong competitors, to judge from their common occurrence in the Alcazar Pool at St. Augustine. The sporadic distribution of *M. olfersii* is clearly a special case, inexplicable except as a result of human intervention, on the basis of our present information.

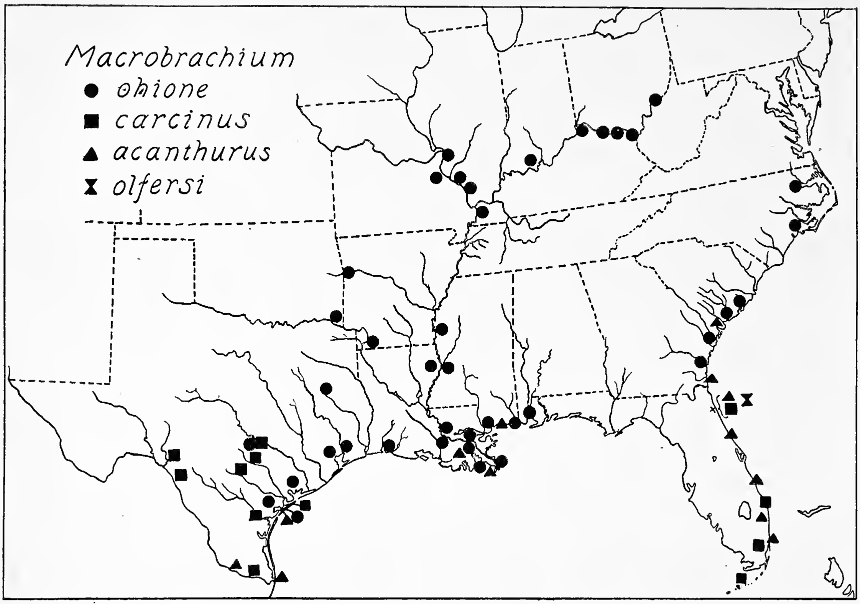


Figure 5. Distribution map indicating the occurrence of *Macrobrachium* in the United States.

An interesting feature of the distribution of M. *ohione* is its apparent restriction to a narrow portion of the South Atlantic seaboard in contrast to its widespread occurrence in the Mississippi below St. Louis, and in the Ohio River as far north as Washington County, far from the influence of salt water (see the distribution map, Fig. 5). It also seems to be absent from Florida. Insofar as tidewaters are concerned, this distribution is much the same as that coastal marine fauna which skips southern Florida and is found on the temperate northern shore of the Gulf of Mexico and the southeast Atlantic coast below Cape Hatteras. This distribution pattern is well indicated in Hutchins' (1947) recent paper on temperature zonation and geographical distribution. The northern distribution of M. *ohione* along the Atlantic coast agrees substantially with the surface isotherm of the minimum monthly mean of 45° F. It may be, in regions where this shrimp is a comparatively recent immigrant, that it is still dependent on bay waters to complete its breeding cycle and is accordingly dependent on these temperature ranges as well as upon salinity. There is opportunity here for investigations on the rate of dispersal of this shrimp in watersheds of the southern Atlantic states which might produce interesting information bearing on the general problem of geographical distribution and dispersal. It is interesting to note that Traubman's records for the occurrence of M. *ohione* in the Ohio River at the northern limit of its range indicate that this species occurs there only during the spring and summer months and that it was taken abundantly only in extreme southwestern Ohio in late May and early June.

Experiments conducted by Pora (1938) on the salinity tolerance of *Palaemon squilla,* at palaemonid of the Black Sea which is found in salinities from 8 to 20 0/00, and also in fresh water, indicated that his material was stenohalin in reaction although the species has a euryhalin distribution pattern. When specimens were exposed to higher salinities, mortality was higher during the early hours of the experiment, but mortality decreased after prolonged exposure to high salinities. The reaction to decreased salinity was the reverse, i.e., low mortality at the onset of the experiment, followed by increasing mortality with prolonged exposure to lesser salinities than the "normal" salinity from which the experimental specimens were collected. The results of this experiment suggest, according to Pora, the existence of physiological species. It would be interesting to conduct similar experiments on *M. ohione,* for it is quite possible that this species, in view of its distribution pattern, has two or more physiological races.

It was formerly believed that *M. acanthurus* and *M. carcinus* occurred on both Atlantic and Pacific sides of Central America, but more critical examination of the material by Dr. Holthuis has failed to substantiate this. Instead, we have pairs of closely related, comparable species:

Atlantic	Pacific
M. acanthurus (Wiegmann)	*tenellum* (Smith)
M. carcinus (Linnaeus)	*americanus* Bate
M. olfersii (Wiegmann)	*digueti* (Bouvier)

There appears to be no Pacific counterpart of *M. ohione.*

Some interest has been expressed in the possibility of artificial propagation of these shrimp. It seems probable that small numbers could be maintained in lakes and spring fed ponds, but as yet our knowledge of the life history of any species is too fragmentary to be of help to fish-culturists. According to Gunter (1937) many apparently mature females of *M. ohione* were not ovigerous during the breeding season, while McCormick (1934) found that ovigerous females also had immature eggs in their ovaries. Evidently the breeding season of *M. ohione* is long, and this information indicates that either some of the shrimp may not spawn until the second year, or that two year old shrimp do not spawn. Further study is necessary to clarify this point, but the small size of many ovigerous females indicates that the second alternative is more probable. The occurrence of *M. acanthurus* in September and October indicates that this species has a later breeding season than *M. ohione.*

Little is known of the food preferences of any other species than *M. ohione.* McCormick (op. cit.) suggested that this species is omniverous and that it has been caught on green willow and cottonwood branches because of its habit of "chewing the green leaves." In Louisiana its food habits are those of the typical shrimp—old meat and dead fish. It will also attack live fish held in live boxes, sometimes "skinning catfish alive" according to Gunter. Probably all of the species are predominantly meat eaters, taking their food as they find it, alive or dead.

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FOOD STUDIES OF BLACK CRAPPIE FRY
(Pomoxis nigro-maculatus)

H. C. Sivells
Biology Department, Southwestern University
Georgetown, Texas

This study was undertaken for the purpose of determining the food of black crappie *(Pomoxis nigro-maculatus)* fry in hatchery ponds, in order to determine which of the zooplankton or phytoplankton are necessary for the growth of these fry so that, by use of proper fertilizer this food supply can be increased, thus increasing production of this species.

This work was done in the State Fish Hatchery at Tyler, Texas with the permission of Mr. Marion Toole, Director of Fish Hatcheries for the Game, Fish, and Oyster Commission of Texas.

The pond selected for this study was Number Twenty-five, located on the west side of the hatchery. It is rectangular in shape, having a surface area of eight tenths acre and ranging in depth from three feet at the south end to nine feet at the north end, in the drain box. The pond was filled in January and one pair of broad crappie placed in the pond in February. Careful observation was made daily for signs of nesting and the nest was first discovered March 7, on the west side of the pond, about forty feet from the south end, in thirty inches of water. The nest was observed daily and on March 16th, the male had left the nest. Although no fry were then seen, it was assumed that the eggs had hatched, and the fry had moved away from the nest. This date is taken as the date of hatching in this paper.

Attempts were made to sample the pond at this stage, but it was not until April 14th that the first fry were caught in dip-nets of fine mesh at the drain box in the north end of the pond. These were placed in labeled bottles containing five per cent formaldehyde and taken to the laboratory, where they were measured for total length and the stomachs removed, placed on glass slides, and opened. The contents were examined under the low power of a microscope, identified, counted and tabulated for each fry. The fish were then grouped in age and length groups as shown in Table I.

On April 14th fifty-eight fry were caught. These were very uniform in size, being three-eighths of an inch, or 10 mm. in length. They were estimated to be approximately 29 days old. Upon examination of the

Table I

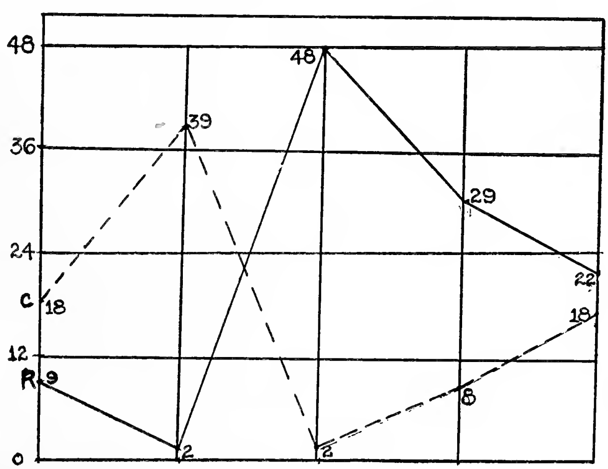
Stomach Contents of Black Crappie Fry

Date	No. of fry	Appr. age days	Length mm	Crustacea Bosmina	Cyclops	Nauplius	Rotifers Polyarthra	Anuraea	Algae Anabena
Apr. 14	58	29	10	393	337	98	174	——	——
May 2	36	47	16	258	403	28	337	——	——
May 2	18	47	19	114	51	58	42	68	——
May 24	21	69	22	18	23	——	——	118	——
May 24	26	69	25	—	58	——	286	247	——
June 6	26	82	28	56	586	238	——	——	140
June 6	41	82	32	47	1103	93	263	435	196
Totals	226			888	2561	515	1102	868	336

stomach contents, it was found that their diet consisted chiefly of crustaceans, such as Bosmina, Cyclops, and Nauplius, with some Polyarthra or rotifers. Some individuals had as many as four Bosmina in the stomach, while others had only one or two Cyclops. The Nauplius and Polyarthra were never more than one to the stomach. It is interesting also that the stomachs from this group contained Bosmina or Cyclops, but never both.

The sample taken on May 2nd consisted of fifty-four fry and here was found a variation in the rate of growth. Thirty-six of these were five-eighths of an inch, or 16 mm., in length and 18 were three-fourths of an inch, or 19 mm., in length. Here again, food continued to be composed mostly of crustaceans, principally Cyclops and Bosmina with a few Nauplius. There was also an increase in rotifers, the Anurarea being the most abundant with only a few Polyarthra present. In this group, however, some of the stomachs contained both the Bosmina and the Cyclops. One 16 mm. fry had four Cyclops in its stomach. This group was forty-seven days old.

On May 24th the third group of forty-seven fry were caught. These



varied in size, twenty-one being 22 mm. or seven-eighths inch in length, and twenty-six being 25 mm. or one inch long. These were estimated to be sixty-nine days old. The stomach contents here did not follow the general pattern of the two other groups. In this group the rotifers make the main diet. Rotifers present were Polyarthra and Anuraea. These were present in far greater numbers than the crustaceans, which were the main food of the two earlier groups. This probably could be accounted for in part due to the rise and fall in plankton populations as shown in the graph. During this period, while the crustaceans were on an increase, the count was still low and there was a large quantity of rotifers present. The graph was based on data taken from weekly plankton counts of the pond, using the counts on, or near, the dates when the fry were caught.

The last group of sixty-seven fry were taken June 6th, at the age of eighty-two days. Twenty-six of these were 28 mm. or one and an eighth inches long and forty-one were 32 mm. or one and a quarter inches in length. In this group the main diet again was crustaceans, Cyclops, Nauplius, and Bosmina in that order. However, rotifers were also used as food by this group in quantity. A third element appeared in the stomachs of this group: Anabena, a blue-green algae which was found in two-thirds of the fry examined. However, there was, at this time, an unusual growth of Anabena in this pond, causing a green coloration in the water.

From the data here presented, it would appear that black crappie feed mainly on zooplankton consisting of small crustaceans and rotifers. While the crustaceans seem to be preferred, the fry can make a diet of either, depending on which is the most abundant in the pond. As they increase in size, they add to their diet phytoplankton, in this case a blue-green algae.

A SUMMARY OF NEW BUTTERFLIES FROM TEXAS

H. A. Freeman
Southern Methodist University
Dallas, Texas

A number of new records for North American Rhopalocera have been found by the writer during the period from 1940-48. These have been published by various authors in three different publications. In order to summarize the data for Texan lepidopterists, only the species found to occur in Texas are listed. The following arrangement is used: the family is listed, with each species in that group being arranged according to generic order, and the publication cited in which the new records appeared.

In addition to these new records five new species and four new subspecies were discovered by the writer in Texas. The same arrangement is followed in listing this group except the type locality for each species or subspecies is also given.

NEW RECORDS FOR NORTH AMERICA FOUND IN TEXAS

PAPILIONIDAE: Papilio lycophron pallas Gray—Ent. News 58(2), Feb. 1947.

EUEIDIDAE: Heliconius petiveranus Doubleday—Ent. News 57(2), Feb. 1946.

NYMPHALIDAE: Biblis hyperia aganisa Bdv.—Ent. News 57(2), Feb. 1946; *Cyclogramma asteria* (G. & S.)—Ent. News 57 (2), Feb. 1946; *Adelpha fessonia* Hew.—Ent. News 57(2), Feb. 1946; *Chlorippe pavon* Latr.—Ent. News 57 (2), Feb. 1946.

RIODINIDAE: Apodemia walkeri G. & S.—Can. Ent., June 1943; *Emesis emesia* Hew.—Ent. News 57 (2) Feb. 1946.

LYCAENIDAE: Thecla bazochii Godt.—Ent. News 57 (2), Feb. 1946; *Thecla cestri* Reak.—Ent. News 58 (2), Feb. 1947; *Strymon yojoa* Reak.—Ent. News 58 (2), Feb. 1947; *Strymon spurina* Hew.—Ent. News 58 (2), Feb. 1947.

HESPERIIDAE: Urbanus doryssus (Swains.)—Can. Ent. 77 (11), Nov. 1945; *Urbanus undulatus* (Hew.)—Ent. News 59 (8), Oct. 1948; *Urbanus auginus auginulus* (G. & S.)—Can Ent. 77 (11), Nov. 1945; *Aguna asander* (Hew.)—Ent. News 56 (4), April 1945; *Aguna asander f. panthius* (H.-S.)—Ent. News 58 (7), July 1947; *Astraptes anaphus* (Cram.)—Ent. News 56 (1), Jan. 1945; *Astraptes hopfferi* (Ploetz)—Ent. News 56 (4), April 1945; *Pellicia bromius* G. & S.—Can. Ent. 77 (11), Nov. 1945; *Pellicia costimacula* H.-S.—Ent. News 58 (7), July 1947; *Spathilepia clonius* (Cram.)—Ent. News 56 (4),April 1945; *Celaenorrhinus fritgaertneri* (Bailey)—Can. Ent. 77 (11), Nov. 1945; *Carrhenes canescens* (Feld.)—Can. Ent. 77 (11), Nov. 1945; *Gorgythion begga pyralina* (Mschlr.)—Ent. News 58(7), July 1947; *Atrytone eulogius* Ploetz—Ent. News 59 (8), Oct. 1948; *Cobalus percosius* G. & S.—Ent. News 59 (8), Oct. 1948; *Lerodea tyrtaeus* Ploetz—Field & Lab. 9 (2), May 1941; *Lerodea edata* (Ploetz)—Ent. News 56 (4), April 1945; *Synapte malitiosa* (H.-S.)—Ent. News 56 (4), April 194E; *Perichares phocion dolores* (Reak.)—Ent. News 56 A1), Jan. 1945.

NEW SPECIES AND SUBSPECIES FROM TEXAS

SATYRIDAE: Euptychia gemma freemani (Stallings & Turner)—Can. Ent. 78: 136 (1946). (Type locality—Pharr, Texas).

NYMPHALIDAE: Asterocampa clyton louisa Stallings & Turner—Ent. News 58 (2), Feb. 1947. (Type locality—Pharr, Texas).

HESPERIIDAE: Celaenorrhinus stallingsi Freeman—Ent. News 57 (8), Oct. 1946. (Type locality—Monterrey, Mexico, allotype, Pharr, Texas); *Thorybes pylades albosuffusa* Freeman—Ent. News 54, March 1943. (Type locality—Ft. Davis, Texas); *Lerodea julia* Freeman—Ent. News 56 (8), Oct. 1945. (Type locality—Pharr, Texas); *Amblyscirtes belli* Freeman—Ent. News 52, Feb. 1941 (Type locality—Lancaster, Texas); *Amblyscirtes erna* Freeman—Ent. News 54, Jan. 1943 (Type locality—Palo Duro Canyon, Texas); *Calpodes evansi* Freeman—Ent. News 57 (8), Oct. 1946 (Type locality—Pharr, Texas).

MEGATHYMIDAE: Megathymus yuccae stallingsi Freeman—Ent. News 54 (9), Nov. 1943 (Type locality—Caldwell, Kansas; paratypes, Lancaster and Palo Duro Canyon, Texas).

NOTES ON HOME RANGES AND POPULATION DENSITY OF TWO SPECIES OF HETEROMYID RODENTS IN SOUTHWESTERN TEXAS

Christopher L. York
The University of Texas

INTRODUCTION

Home ranges of the Merriam pocket mouse *(Perognathus merriami gilvus)* and the four-toed kangaroo rat *(Dipodomys merriami merriami)* were studied by live trapping and marking in northern Presidio County, Texas from June 9 to July 8, 1948. Thirty-one kangaroo rats were caught a total of 200 times, and 35 pocket mice were caught a total of 172 times on a 27.81 acre plot. This plot was located in the catclaw-tobosa association of the Plains life belt of the Sierra Vieja biotic district (York, 1949).

The trapping was done on the C. Espy Miller ranch, about 10 miles west of Valentine. Several members of the University of Texas 1948 field party participated in the field work here reported, and I am indebted to them for their contribution to this report.

DESCRIPTION OF THE TRAPPING AREA

The plot was located on the ZH Canyon alluvial fan, in pasture No. 18, on which sheep were being run. The ground was fairly level. No large ditches ran through the original plot, but a braided stream pattern existed with finger-like rows of boulders ranging in size from 18 inches in diameter downward, the intervening space being filled with finely divided soil, derived from volcanic ash and decomposed igneous rocks. Catclaw *(Acacia greggii* Gray) and tobosa grass *(Hilaria mutica* (Buckl.) Benth.) made up the majority of the vegetation, while the narrow-leafed yuccas (Yucca elata Engelm.) were scattered throughout the area. Occasional corrodentia, also known as tassajillo, *(Opuntia leptocaulis* DC.), crown of thorns *(Koberlinia Spinosa* Zucc.), creosote bush *(Larrea tridentata* (D) Coville), barberry *(Berberis trifoliolata* Moric.), sumac *(Schmaltzia microphylla* Small), black grama *((Bouteloua eriopoda* (Torr.) Torr.) covered most of the surface; however, some spots were completely bare. After a slight rain which fell during the course of the study, grass seedlings sprouted, along with those of *Portulacca* sp. and others; but all soon succumbed to the dryness and summer heat. Clumps of catclaw varied in size from a single small bush of no more than two feet in diameter to numerous bushes covering spots as great as 15 feet in diameter. The level of the soil was usually higher within these clumps than in the open. This can be attributed to the binding of blowing, or washing, sand and debris about the bushes and to the action of rodents and other animals in digging dens under this protection. Certain grasses and forbs, not otherwise manifest, could be found here also, protected from the grazing of cattle and sheep.

The kangaroo rat and pocket mouse were the only small rodents recorded from the plot. Some six or eight jackrabbits were observed feeding on the plot each day. Numerous lizards were collected from the trap area. These were the blue-bellied racer *(Cnemidophorus perplexus)* and horned lizards *(Phrynosoma cornutum)* and *(P. modestum)*. Snakes included the racer *(Coluber flagellum testaceus)*, the common bull snake *(Pituophis catenifer sayi)*, the Big Bend patchnosed snake *(Salvadora hexalepis deserti-*

cola) and the Davis Mountain rat snake *(Elaphe subocularis)*. All these snakes and lizards, with the possible exception of the horned lizard, use mouse and rat burrows for dens. The snakes definitely enter into the ecological aspect of the population density of the heteromyids. Three predator birds were seen in the area, namely the horned own *(Bubo virginianus)*, Swainson's hawk *(Buteo swainsoni)* and the red-tailled hawk *(Buteo jamaicensis)*.

METHODS

A trap plot was laid out in a grid pattern with numbered stakes one hundred feet apart. The plot measured 900 feet by 900 feet, and had an area of approximately 18.62 acres. Traps, designed for live-capture, constructed of galvanized iron, after the model described by Blair (1941) were placed in the immediate vicinity of the stakes, under what were judged to be optimum conditions for catching the animals. In some cases the sets were as far as 10 feet from the stake, but usually they were closer. The traps were cleared from the quadrat after a period of four weeks and placed in a ring, at numbered stakes, one hundred feet outside the original plot. The hundred-foot interval between traps was maintained. This ring of traps was run for two nights, after which the traps were moved another one hundred feet outward and run for two more nights. This arrangement actually did not have the corners covered since no additional traps were used to encompass the area 1100 feet by 1100 feet, or 27.81 acres. Such procedure was intended to determine the members of the populations whose ranges extended outside the original plot. Normally all traps were set for six night per week, leaving them in the sprung position each Saturday morning and resetting and rebaiting late Sunday afternoon. When a given animal had been captured in the same trap for three successive nights, the trap was left sprung; hence the rodent would of necessity be forced to wander elsewhere the following night. Traps were left closed during the day to prevent the accidental capture of animals, which would have resulted in their death during the high daytime temperatures. Bait used during this study consisted of a mixture of wheat, milo maize, and corn chops. Large red ants were numerous in the area and carried off considerable quantities of bait, necessitating use of greater portions than should have been sufficient under conditions of non-competition. These ants were also responsible for the death of several animals which had evidently been caught early enough after the set was made to give ample time for the ants to stupefy or even kill and partially destroy the carcasses. The entry of the ants into the traps was also the probable cause of catching several lizards, which evidently were seeking ants as food.

The traps were run each morning at an early hour, before temperatures became fatally high. The animals were examined for sex and apparent age, and then marked if they had not been previously caught. Kangaroo rats were marked by punching notches in the edges of the ears and by clipping toes in accordance with a predetermined pattern to indicate the field number of the animal. The pocket mice were marked by clipping toe tips in conjunction with a single ear punch.

Upon release of the animal, it was followed to its hole. The distance and location of each hole from the stake was recorded. The kangaroo rats frequently appeared to be somewhat lost when first released, but after a short interval of becoming oriented they would find a trail to the nest.

Each animal apparently had several dens. Any hole in which an animal remained for several minutes was considered its den. Animals were observed to desert burrows shortly after entry in favor of others which were not necessarily those they had previously occupied.

HOME RANGES OF POCKET MICE

Ten or more captures were considered sufficient for the determination of the home ranges of any animal. Of the 36 pocket mice caught only five (three males and two females) were captured 10 or more times. These five were caught an average of 13 times, the greatest number of times being 15 captures for number five, a young female. These five animals were caught in twenty different traps for an average of four traps per mouse. Refuge was sought in twenty-one different holes for an average of about four holes per mouse.

Home ranges were determined by use of the method described by Blair (1940) allowing half the distance from the trap to the next trap outside of the range. The greatest area occupied by a pocket mouse (a young female) was 5.40 acres. The smallest range was that of a young adult male caught thirteen times in only two traps to give an area of only 0.46 acres. This animal took refuge in only four dens, while number five utilized five holes. The average home range for the males was 1.88 acres, while that of the two females was 4.88 acres, or more than twice the area covered by the males. The numbers are too few, however, to indicate whether or not this difference is significant.

Only three individuals captured within the original plot were caught in the outer rings during the last four days. Number 18, a young adult male, was the only one of these considered in home range calculations, with 14 catches in two traps within the original plot. This mouse was caught in both of the outer rings.

Examination of areas occupied by individuals caught less than ten times is of interest. Of six pocket mice (three males and three females) taken seven to nine times, the males average 2.53 acres. This is approximately 1.7 times as great as the average area occupied by the males which were captured 10 or more times. The females averaged 3.89 acres, or about one-fourth less than the area occupied by the females captured 10 or more times. Number four (a female), taken eight times in six different traps, had a home range of 5.72 acres, which was equal to that of number five (a female) which was taken 15 times. It should be pointed out that while validity increases with the number of times an animal is captured the home range does not necessarily expand.

When considering the location of the dens in relation to size of home range the results were somewhat different from the above figures. Calculation of the home ranges in this case were made assuming a distance of one-half that between traps beyond the den (50 feet) and including the traps visited. In each case the home range was greater than if calculated on the basis of trap location alone. The increase in the case of mouse number three amounted to 1.16 acres. The males were found to occupy an average area of 1.88 acres as compared with the females with 5.86 acres. This averages 3.47 acres when disregarding sex.

During the period of almost five weeks the 27.81 acres was found to have 35 pocket mice living on the plot, or one mouse per 0.79 acres. This figure is not absolute since all mice were not captured on the same day. The greatest number of mice captured during a single week was 59 during the second week. Forty-six were caught during the fourth week. Thirteen were captured the first week, forty the third week and seventeen during the fifth week. Some individuals apparently were passing through the area and were captured a single time only or fell prey to hawks, owls or other predators. The probability of the animals becoming wary and refusing to enter traps is very doubtful. There is some evidence of their becoming "trap-bums" learning to rely on the bait for sole source of food. Two were known to have died in the traps.

HOME RANGES OF KANGAROO RATS

Home ranges of kangaroo rats were determined in the same manner as for pocket mice. Four males were caught 56 times in 26 different traps for an average of 14 captures per animal. Refuge was sought in 29 holes. The average range was 6.38 acres. The largest comprised 8.39 acres, and the smallest comprised 2.90 acres. Four females were captured 40 times for an average of 10 captures per animal. Twenty-four traps were entered by these females. The average home range in this instance was 3.39 acres which was only a little more than one-half the area occupied by the males. The least area comprised 1.15 acres, while the largest comprised 5.39 acres.

Examination of the trapping records of three animals is of special interest. Number 10, a male, had ranged consistently in the southwestern corner of the plot, having been captured 15 times in six traps. On the second morning after placing the first ring about the area this animal was found in a trap diagonally across the plot. The distance of movement from the last trap entered was approximately 1,200 feet. Number 15, a female, had occupied a range in the southeastern portion of the quadrat prior to the change of layout. On the first morning after placing the inner ring she was found in a trap immediately outside the regular range, about 150 feet from the trap last occupied. The second morning this animal was found 1,240 feet across the quadrat. This was the last time the animal was caught. Number 14, a male, which had ranged along the northern edge of the quadrat was captured in the inner ring on both mornings it was run. The place of these captures was only 240 feet from where it was previously caught. The second day of running the outer ring this male was caught about 580 feet from where it was taken in the inner ring.

As in the case of the pocket mice, home ranges calculated from the trap data alone were found to be smaller than those taking den location also into consideration. The males were found to have an average home range area of 6.89 acres as compared with a range of 6.38 acres based on trapping alone. The females had an average estimated range of 4.26 acres against a range of 3.39 acres from the trap data. The most outstanding example of gain in size of home range due to calculation method was that of Number 16. This animal was captured 12 times in four traps which were located along the south edge of the quadrat. Calculations from the trap records gave an area of only 1.15 acres but consideration of den locations increased the area to 2.60 acres.

Comparison of average range size of the males to that of the females shows the males to have covered 1.57 times the area covered by females. The greater number of captures, 59, was during the second week, with 45 and 43 during the third and fourth weeks respectively. The first week of only four days netted only 29 animals, while the fifth week, of only four days, with traps circling the main plot gave 25 animals.

SUMMARY

Thirty-one kangaroo rats *(Dipodomys merriami merriami)* and thirty-five pocket mice *(Perognathus merriami gilvus)* were live-trapped and recaptured 200 and 172 times respectively on 27.81 acres of desert scrub land in northern Presidio County, Texas. The plot was on the catclaw-tobosa association as defined by the field party. The density of kangaroo rats was found to be one male per 1.63 acres and one female per 1.91 acres. The density of pocket mice was one male per 1.65 acres and one female per 1.46 acres. Five pocket mice were captured 10 or more times. The average home range of three males, computed from trap data was found to be 1.48 acres and that of two females was 3.90 acres. Consideration of den location in combination with the trap records indicated larger home ranges as follows: males 1.88 acres and females 5.87 acres. Six pocket mice captured seven to nine times had average home ranges of 2.53 acres for the males and 3.89 acres for the females. No increase was found when considering den location of these males. Only one female extended its range to give an average of 3.94 acres. Of thirty-one kangaroo rats caught eight were captured 10 or more times. The average home range based on trap records for four males was 6.38 acres, and for four females it was 3.39 acres. When considering den location in conjunction with trap records the average range of the males was 6.89 acres and that of the females was 4.26 acres.

Home ranges of males were found to overlap, but there was no evidence of sharing dens. Females were likewise found to have overlapping ranges, and again there was no apparent sharing of dens. Ranges of males and females were found to overlap, which would be assumed to be the normal procedure during the months of June and July.

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THE PHYSICAL AND VEGETATIONAL BASIS FOR ANIMAL DISTRIBUTION IN THE SIERRA VIEJA RANGE OF SOUTHWESTERN TEXAS

Christopher L. York
The University of Texas

INTRODUCTION

A survey of the ecological distribution of the vertebrates was made in the Sierra Vieja region of southwestern Texas from June 3 to July 9, 1948. The survey party numbered 22 members under the direction of Dr. W. Frank Blair. The individual members of the party undertook various projects designed to cover the several phases of the whole problem. A. W.

Anderson studied feeding habits of the mule deer; Clay E. Miller, Jr., J. B. Nance and the late Harry E. Steincamp trapped the larger mammals; Homer W. Phillips, Wilmot A. Thornton and John W. Duke, Jr. specialized on the birds of the area; Alvin G. Flury, D. L. Jameson, T. M. Burke and A. L. Carroll concentrated on the reptiles and amphibians; J. L. Reagan and Sam M. Awalt studied the pocket gopher populations and habits; R. S. Osborn studied the habits of the rock squirrels; while Robert Zschappel, R. J. Kemp, Paul W. Collier, W. W. Webster, Keith E. James, Ralph E. Fuge, Virgil H. Roan and the author investigated the small mammals. The present report considers the physical environment and vegetation of the Sierra Vieja region.

ACKNOWLEDGEMENTS

We are much indebted to C. Espy Miller and family for the privilege of using the old army cantonment as housing for the expedition, and for the use of the ranch as the area of principal study, as well as for other courtesies too numerous to mention and to B. C. Tharp for aid in the determination of the plants collected in the area.

EARLIER INVESTIGATIONS

Botanists as well as zoologists who have visited this area are few in number. Great distances over poor roads and with little means of natural support have discouraged all but the most hardy. Early biological explorations in Trans-Pecos Texas were more or less incidental extra-activities of a few interested members of boundary survey parties sent out by the United States Army. Dr. Valery Havard, U. S. A., reported his observations which covered the period from 1880 to 1883. His report in two parts described in a general manner the vegetation of western and southern Texas and pointed out the possible value of the area and its vegetation to agriculture and industry. He included a brief description of the topography and also the limited meteorological data accumulated to the time of writing.

Ecological observations have been reported by Neally (1880); later by Bray (1901:207; 1905:7; 1906:76); also by Bailey (1905:33); and by Carter and Cory (1932:24). The most intensive treatment, limited to a small area, was given by Cottle (1931:105; 1932:121). Dr. Mary S. Young was probably the first well trained botanist to investigate the flora. Death halted her research while she was still in her prime. Unfortunately her field notes remain unpublished (1914).

W. Frank Blair did intensive bioecological investigations in the Davis Mountains (1940). L. C. Hinckley has done considerable work in the Trans-Pecos (1944) having pointed out the contrasts in the vegetation of the Sierra Tierra Viejas (1947). He is continuing investigations as an avocation while teaching in Sul Ross College, Alpine, Texas. Working with Hinckley is Barton H. Warnock of the same college faculty. L. H. Shinners, V. L. Cory, Eula Whitehouse and C. L. Lundell with various associates have worked under the auspices of Southern Methodist University. Marjorie Anthony, of the University of Michigan, devoted about five months of 1948 investigating the *Cactaceae* of the Big Bend. The author and associates spent only five weeks during the drier portion of the summer, hence the sample obtained can not be considered as fully representative.

PHYSIOGRAPHY

The Sierra Viejas, likewise referred to as the Tierra Viejas, or the Sierra Tierra Viejas, are located in the Basin and Range Physiographic Province of Fennemann (1931) and the Mexican Plateau Region of the Cordilleran Plateau of Atwood (1940). They lie between the Chinati Mountains to the south and the Van Horns to the northwest, roughly paralleling the Rio Grande in the upper Big Bend territory. These three ranges are somewhat en echelon in arrangement. The Sierra Viejas extend from western Jeff Davis County southward into Presidio County for a distance of approximately 40 miles, between 30 degrees and 12 minutes and 30 degrees and 45 minutes north latitude and 104 degrees 32 minutes and 104 degrees 48 minutes west longitude. The trend is in general north-northwest to south-southeast, which is characteristic of most of the mountains of this province. This range is composed of eastward dipping volcanic rocks of Tertiary age, to the east of which is found the Valentine Plain and to the west, below the Rim Rock, the Rio Grande Plain (Fig. 1). The Valentine Plain occupies an aggraded basin having an elevation of approximately 4500 feet. The Sierra Viejas attain an altitude of about 6467 feet in Vieja Peak (Fig. 1). Several other peaks are above 5000 feet, all being the result of differential erosion of fault blocks.

The drainage pattern is largely consequent, with the canyons north of Vieja Pass incising their channels in an east-west direction; however, to the south where the uplift was the greatest, the tendency is almost in a north-south direction; for example, the major portion of ZH (Zeb Holland) Canyon flows northward to join Cottonwood Canyon, which comes from a northwesterly direction and continues eastward to the Valentine Plain (Fig. 2). Musgrave Canyon, located on the southern slope empties onto the Rio Grande Plain. In the vicinity of the Miller Ranch the chief canyons include Knox, Box, Fox Hollow, Canyon 96, and West Well Canyon in addition to those previously named. All of these canyons empty onto the Valentine Plain. Such a pattern is typical of the drainage systems of this physiographic province. Wide alluvial fans are found at the mouths of the canyons, their surfaces being covered with boulders of varying sizes beside the braided channels, with intervening areas filled with graded, finer sediments. Such surface features indicate a history of numerous flash floods, with the possibility that at some earlier time in Tertiary history the area may have been subjected to periods of much heavier rainfall than at present.

The Valentine Plain is apparently flat (Fig. 2); in fact, it gives the impression of sloping toward the mountains, except for the indications in the washes. Ranchers, with the assistance of the Soil Conservation Service agents, have done considerable work in reducing mass wasting of the surface soils. The northward flowing Chispa Draw and its tributary, Capote Draw, both intermittent streams, are the principal drainage members within the Plain. During the greater portion of the year their channels are dry.

The Rio Grande Plain is a highly dissected depositional surface drained by various tributaries of the river. Green River, also known as Van Horn Creek, and Capote Creek with its tributary Walker Creek are the principal branches within the vicinity of our work. These streams are gradually eroding the mountains, pushing the Rim Rock to the east, which process will eventually give outside drainage to the Valentine Plain.

GEOLOGY

The southwestern Pecos area has not been closely examined by geologists except in a limited number of locations. Information available is largely the outcome of reconnaissance projects; for example Baker (1927) covered about 35 sections per day when checking this area. In recent years graduate students of the University of Texas Department of Geology have investigated small tracts on a more intensive scale.

Following the withdrawal of Upper Cretaceous seas this area was covered by terrestrial alluvia. During the last portion of Cretaceous times the Rocky Mountains were born, and some effects were doubtless felt within this portion of the Trans-Pecos area. However, the Sierra Viejas are probably of later origin, from intermittent volcanic activity which occurred during late Cretaceous and early Tertiary, covering the older sediments with layers of various volcanics. Erosion between eruptions is believed to have virtually erased certain layers, leaving scant remnants in isolated spots to indicate existence of once more extensive areas. The Rim Rock country possesses rhyolitic volcanics of as much as 4,000 feet thickness, of which over half is tuff. Lava flows varying from acid to very basic are interbedded with tuffs, tuff breccias and sediments. The Rim Rock ridge or cuesta is composed of a rare volcanic rock known as quartz-pantellerite. Fresh surfaces of this rock show a greenish, finely crystalline, ground mass surrounding orthoclase phenocrysts. Weathered surfaces of this rock are dull, orange yellow to reddish brown. Sills and dikes of considerable number have been intruded into the sediments and volcanics.

Some of the most extensive faulting of the Trans-Pecos occurred in the Sierra Viejas during Mid-Tertiary. One long fault is responsible for the origin of the Rim Rock, formed by the upthrust block. Erosion of the softer sediments below, aided by the structure of the volcanics above, has moved the scarp to the east as much as six miles in places (Baker 1927:52). Tilting of this block produced an interior drainage basin to the east between the Sierra Viejas and the Davis Mountains. The filling of this basin with detritus from the slopes has formed what is referred to as the Valentine Plain or Chispa Flat. In numerous ranch wells stock water is obtained at various depths. Bed rock was encountered in a well at Valentine at 872 feet.

The area between the Rim Rock and the mountains across the Rio Grande, following the orogenic action of early Tertiary, became a lake; in fact, at various times the valley drained by this river has been a series of lakes reaching from the vicinity of Presidio to El Paso and beyond. During the lake stage lacustrine sediments were laid down ranging from fine silts to coarse conglomerates. When at last the river cut its canyons to drain these lakes, erosion of the lake bottom deposits rapidly cut the area up into the rough condition which has been maintained through rejuvenation. Numerous faults within the area account for some of the escarpments of the plain. Anticlines, which were the result of folding during Mid-Tertiary, have been eroded to produce other scarps. Absence of triangular facets indicates lack of faulting within recent times.

SOILS

The soils of the area have been described by Carter (1931: 168-178) as Reeves and Verhalen in the basins, with Rough Stony Land and Brewster soils on the mountains. Soils along the Rio Grande are designated as Gila. Reeves Soils are characterized by light brown to ashy-gray calcareous surfaces which grade into calcareous subsoils of light shades of yellow or buff color. Very sandy soils may have a very low organic content, having been developed under arid or semi-arid conditions. The structure is open allowing rapid penetration of air and water. The texture ranges from sandy to silty-clay loam with areas having considerable gravel. The surface is almost devoid of grass, creosote bush *(Larrea tridentata* (DC.) Cav.) being almost the only species capable of maintaining itself in appreciable amounts.

Verhalen soils are characterized by chocolate brown or reddish-brown surface soils, grading into reddish subsoils which rest on almost pure, white calcium carbonate or pinkish calcareous clays. Near the igneous mountains, such as the Sierra Viejas, Verhalen Clay and Clay Loam are the chief soils of the series. Thick growth of tobosa grass occupy these almost flat surfaces and are referred to as "tobosa flats." The texture of these soils is fine and the areas are so nearly flat that water may stand for some time following a rain.

Brewster Soils are poorly developed, very thin, stony soils which are red or reddish brown in color, resting upon bed rock or broken rock particles. Stony loam occurs on the foothills and smoother areas of the igneous mountains. The admixture of broken stone aids in water penetration; however, the amount of soil present is never great due to erosion. Grama grasses are usually plentiful on these soils.

The roughest, most precipitous areas are designated as Rough Stony Land. Bluffs, narrow canyons, steep slopes and some areas of rolling table lands are included in this category. A fairly good cover of grama grass, constituting good range, occurs on igneous surfaces, whereas corresponding cover on limestone surfaces affords poorer range.

Gila soils are limited to narrow strips along the Rio Grande. These soils have been utilized as farm land. Surface soils are grayish-brown, light brown or brown. Subsoils are of slightly lighter shades of the same colors as the surface soils immediately above. A limited amount of organic matter is present in these calcareous friable soils.

CLIMATE

The climate of the Sierra Vieja Range is arid to semi-arid, lying within the region of 10-15 inches of mean annual rainfall (Kincer 1922: 6-7). No class A Weather Bureau station is located near the area of study, and records are limited to those of precipitation taken at Miller Ranch Headquarters by the owner in cooperation with the Weather Bureau. These data cover a period from 1937 to date, and unfortunately are incomplete in that no records were made during several months (this is also true of numerous other cooperative station records). Since there are no records of temperature, cloud cover, frost free days, wind direction, etc., available for the specific area, data, in so far as possible, from neighboring collection points are offered for comparison.

Length of frostless season for the Sierra Viejas has been assumed as comparable to that of the Davis Mountains to the east by Hinckley (1947: 163) who offers data obtained at Mount Locke Observatory, altitude 6791 feet, showing about 200 days as an average. Hinckley believes a somewhat longer period would prevail on Vieja Peak with only 6467 feet altitude.

Table I

Selected Climatological Data for Four Stations in and near the Sierra Vieja Region, Southwestern Texas.

MEAN TEMPERATURES

Yearly	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Alpine (1931-1948)													
	45.9	51.0	56.1	63.2	70.6	77.0	76.3	71.2	65.0	54.0	48.5	63.0	62.9*
Presidio (1931-1948)													
	48.9	55.5	61.4	68.2	77.1	85.0	85.3	84.5	78.9	70.6	57.2	50.1	68.7

* Annual mean based on years with complete data only.

RAINFALL

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual MEAN
Presidio (1931-1948)													
Inches	0.55	0.22	0.19	0.39	1.04	1.15	1.31	1.42	1.76	0.89	0.36	0.55	9.87
%	5.53	2.23	1.92	3.95	10.54	11.65	14.28	14.38	17.84	9.01	3.62	5.53	
Balmorrhea (1923-1945)													
Inches	0.48	0.64	0.48	0.70	1.32	1.53	1.78	1.98	2.34	1.70	0.58	0.75	13.57
%	3.53	4.71	3.53	5.08	9.73	11.30	13.10	14.60	17.20	11.80	4.30	5.50	
Alpine (1931-1948)													
Inches	0.88	0.47	0.28	0.55	1.72	2.44	2.65	2.54	2.83	1.22	0.50	0.88	17.14
%	5.13	2.74	1.63	3.20	10.00	14.23	15.46	14.81	16.51	7.11	2.91	5.13	
Miller Ranch (1937-1948)													
Inches	0.72	0.56	0.44	0.54	1.07	1.94	2.14	2.36	2.53	1.78	0.67	0.82	14.43
%	5.04	3.19	3.05	3.80	7.41	13.44	14.13	16.35	17.53	12.33	4.71	5.69	
1948 in.	0.13	0.27	——	T	0.14	2.16	0.63	1.19					

Such data can hardly be considered comparable to conditions existing on the Valentine Plain or in the Rio Grande Basin biotic district due to greater altitude differences. Frost data are available from Alpine indicating an average of frostless period of 225 days over an interval of 17 years. Presidio, on the Rio Grande, has recorded an average period of 234 days during the same interval. A difference in altitude is to be considered as well as the difference in latitude, as ample reason for the longer season at Presidio. Actually a number of years record no late frost at either station, but rather the last day on which ice was observed.

Alpine, from 1931-1947, lists an average of 200 days of clear skies against 113 partly cloudy and 52 cloudy days, with 75 days producing measurable rainfall. Records for Presidio during the same years are incomplete; however, an average of 37 rainy days is listed. It is highly probable that the conditions on the eastern slopes of the Sierra Viejas and adjoining valleys would be similiar to those at Alpine, while the Rio Grande Basin district of this study would resemble the conditions at Presidio to a greater extent than those at Alpine.

Temperature data for the same two stations are available showing a mean annual temperature at Alpine of 63 degrees F. (Table 1) as compared with 68.7 degrees F. at Presidio (Table 1). The former is noted for its mild summer temperatures while the latter is known for its contrastingly high readings. Records of June, July and August 1948 at Presidio showed monthly mean temperatures of 105.0 degrees F., 102.3 degrees F. and 102.3 degrees F. for these respective months against 79.4 degrees F., 78.7 degrees F. and 79.1 degrees F. at Alpine for the corresponding months. These means taken at Presidio are not typical of all years, but are the highest figures shown during the period of record. Recording thermometers were not maintained by the field party during the study; hence it can only be assumed that the area experienced temperatures between those observed at the two mentioned stations.

Alpine shows an average of 17.14 inches of rainfall per year over the past 17 years, 61% of which has been recorded during the months of June, July, August and September (Table 1). Balmorrhea on the northeast side of the Davis Mountains, at an elevation of 3225 feet, shows an average of 14.57 inches per year (1924-1945). Fifty-six percent of this precipitation fell during June, July, August and September. Presidio records for the seventeen year period indicate an annual average of 9.87 inches, with 58% occurring during June, July, August and September. Miller ranch records covering the years 1937 to date are incomplete, but indicate 14.43 inches precipitation falling during the period.

As Hinckley has suggested (1947:155), precipitation can be assumed to be heavier higher on the slopes of the Sierra Viejas than at the ranch headquarters. Mesophytic vegetation on these slopes supports this assumption. Some indication of cycles of maxima in precipitation for the region are noted (Fig. 2), Alpine and Balmorrhea having received greatest amounts during 1932 and 1941; however, an insufficient span of years of recording precludes any definite statement as to the existence of such a cycle. Presidio data do not show comparative trends in 1932 but correspond very closely in 1941. Shorter records at Miller ranch headquarters correspond fairly well in trend with those at Alpine and Balmorrhea; hence the dry season experienced during the summer of 1948 should have been anticipated, and will probably be repeated in 1949. Should the repetition occur, an above average record may be expected in 1950.

During the first five months of 1948 the precipitation recorded at the Miller ranch amounted to only 0.54 inch. On June 1st. a rain of 1.45 inches fell which accounted for the general greenness of the range at the time the field party arrived on the third day of the month. Seedlings of both grasses and forbs appeared, but since there was no more rain until the 12th of the month when 0.03 inch fell these dried up. On June 19th a rain of 0.13 inch fell to be followed by 0.17 inch on the 20th. Seedlings again appeared and grew for a short time before wilting and dying. Perennials put out fresh growth and the range looked fair for a few days. The next rain, amounting to 0.08 inches, fell on July 6th. The area is characterized by having showers in the summer afternoons. Mornings are usually clear, with clouds gradually building up over the Valentine Plain and drifting about over the area until sometime in the afternoon when showers occur. This gives a spotted rainfall which has been aptly described by Havard (1885:451) "There is no well-defined rainy season in Western Texas; rainfall in fitful 'spells' at any, and often the most inopportune, time, with long intervals of drought. Two or three months receive one-half of the yearly precipitation. It is the season of sudden rises and floods which, in a few hours, cause irreparable damages and again as promptly subside, drained away by timberless arroyos, so that but a comparatively small amount of moisture is retained in the earth and penetrates into the subsoil."

Evaporation data for Balmorrhea only are available for the period of study. June evaporation was 12.57 inches. Unfortunately there was no record made of precipitation during this month for comparison. During July, 1948, evaporation amounted to 10.56 inches as compared with 0.85 inches of precipitation. It may be assumed that a similar condition exists at the other stations since the amount of cloudiness and insolation is comparable. In the light of the various similarities in data at the neighboring stations it is assumed that a correlation exists also at the Miller Ranch.

VEGETATION

This area has been included in "Creosote Bush (Southern Desert Shrub)" region of the United States by Shantz and Zon (1924:23), while Tharp (1928:17-24) in his dividing the state into regions of natural vegetation assigned it to the "Sotol-lechuguilla" and "Mountains" regions.

BIOTIC PROVINCES AND LIFE BELTS

The Chihuahuan biotic province as designated by Dice (1943:4) comprising all Trans-Pecos Texas, portions of the Pecos and Rio Grande valleys of southern New Mexico, and the major portion of the Mexican Plateau Region, includes the area covered by this study. The Sierra Viejas, with the valley to the east, is designated as the Sierra Vieja biotic district, while the area along the Rio Grande, due to its differences is designated as the Rio Grande Basin biotic district.

Biogeographical units recognizable in mountainous regions have been designated by Dice and Blossom as life belts (1937:45) which are thought to be the outgrowth of climatic differences resulting from varied elevations and exposures. A life belt is characterized by one or more ecological associations and is a subdivision of a biotic district. Similar biotic districts may contain very similar life belts, modified only by their peculiarities of elevation and exposure and by other physical differences. The Sierra Vieja district may be divided into two easily recognizable life belts similar to those designated by Blair (1940:8) in the Davis Mountains. The Valentine Plain, lying between the Davis Mountains and the Sierra Viejas, is designated as the plains belt, while the mountains proper are designated as the roughland belt. The latter differs from that of the Davis Mountains roughland belt in being only 6467 feet high (Vieja Peak) as compared with the 8382 feet altitude of Mt. Livermore (Fig. 1). The Rio Grande plain biotic district may also be divided into the flood-plain belt and the upland belt, well marked vertical entities.

PLAINS LIFE BELT

The Plains life belt may be considered to comprise the areas of 5000 feet elevation or lower. The associations recognized in this belt are seven in number, of which the tobosa-grama covers the greatest area, while the catclaw-tobosa association is second in size.

CATCLAW-CEDAR ASSOCIATION

This association may be found at the mouths of the larger canyons, for example, that of ZH Canyon. The soil is thin, and is covered with a heavy shingle of water deposited boulders. Practically all the soil is the result of depositional action by the waters of the intermittent streams. The rough, rocky surface enables rainwater to enter more readily than would be possible if the rocks were absent. This factor is responsible for the vegetation of greater size than is supported farther out on the plain or between the allluvial fans near the base of the mountains.

A 100 x 100 foot quadrat was found to support the following listed species: 80 catclaw *(Acacia Greggii* A. Gray); 42 cedars *(Juniperus monosperma* Engelm.); 5 Yuccas *(Yucca Torreyi* Shafer); 3 prickly pears *(Opuntia Engelmannia* Salm-Dyck); approximately 15% grass cover. These grasses consisted of tobosa grass *(Hilaria mutica* (Buckl.) Benth.); three awns *(Aristida* sp.); grama grasses *(Bouteloua* sp.) and bluestems *(Andropogon* sp.). Other shrubs were *Ephedra* sp.; mesquite *(Prosopis juliflora* (Swartz) DC.; barberry *(Berberis trifoliolata* Moric.); *Opuntia arborescens* Engelm.; *Krameria parviflora* Benth.); white brush *(Aloysia lycioides* Cham.). Forbs include *(Rhynchosia texana* Torr. and Gray); *(Eriogonum* sp.); *(Talinum aurantiacum* Engelm.); (*Commelina dianthifolia* Delile); Croton *(Croton corymbulosus* Engelm.); *(Lactuca* sp.); *(Dichondra argentea* Willd.).

CATCLAW-TOBOSA ASSOCIATION

Beyond the Catclaw-cedar association from the canyon mouths one finds the Catclaw-tobosa association. This association occupies the portion of the Valentine Plain made up of medium coarse gravels to fairly fine sediments, and only scattering strings of larger boulders. The surface is somewhat level and is covered with 62 catclaw *(Acacia Greggii* A. Gray) clumps of varying size. Between these clumps is found approximately 50% cover of grasses. The predominant Tobosa grass *(Hilaria mutica* (Buckl.) Benth.) makes up about half of the total grass cover. Grama grasses *(Bouteloua hirsuta* and *B. curtipendula* (Michx.) Torr.), three awns *(Aristida* sp.), Bluestem *(Andropogon* sp.), panic grasses (*Panicum* sp.), are all scattering about largely under the protection of the catclaw. The quadrat, 100' x 100', also had the shrubs: three *(Yucca elata* Engelm.); one *(Opuntia leptocaulis* DC.); barberry *(Berberis trifoliolata* Moric.); six *(Ephedra* sp.) prickly pear *(Opuntia Engelmannia* Salm-Dyck); Forbs included *(Talinum aurantiacum* Engelm.); *(Lactuca* sp.; *(Cucurbita foetidissima* H.B.K.); *(Apodanthera undulata* Gray); *(Solanum elaegnifolium* Cav.); *(Commelina dianthifolia* Delile); *(Ipomoea* sp.); *(Portulacca* sp.); *(Sida neomexicana* Gray); and *(Croton corymbulosus* Engelm.).

TOBOSA-GRAMA ASSOCIATION

The tobosa-grama association occupies the areas of the Valentine Plain composed of the more finely divided sediments. These soils are generally found toward the center of the plain from the catclaw-tobosa association where the waters coming from the mountains had lost their velocity and the silt settled out after the coarser sediments had been left behind. Only occasional individual shrubs are found, with almost 100 per cent grass cover except for areas denuded by overgrazing, or due to erosion which is in reality the outcome of the effects of overgrazing. Practically pure stands of tobosa grass *(Hilaria mutica* (Buckl.) Benth.) alternate with grama grasses *(Bouteloua hirsuta* Lag.) and *(B.* sp.). Along the washes some few forbs are to be found including ironweed *(Vernonia marginata* (Torr.) Raf.), stink weed *(Helinium* sp.), etc. but these are outstandingly limited in number.

CREOSOTE BUSH-CATCLAW-BLACKBRUSH ASSOCIATION

The creosote bush-catclaw-blackbrush association is typified by an area near the Roosevelt well (in pasture number 16 of the Miller ranch). The soil is alluvial fan deposits comprised of fairly coarse particles mixed with some finer sediments and caliche encrustations occurring in spots. Generally speaking there is a high degree of porosity. Check quadrats showed a predominance of catclaw *(Acacia Greggii* Gray); creosote bush *(Larrea tridentata* DC.) Cav.); and blackbrush *(Microrhamnus ericoides* Gray). Other shrubs include huisache *(Acacia constricta* Benth.); narrow-leafed yucca *(Yucca elata* Engelm.); *(Yucca Torreyi* Shafer); *(Opuntia leptocaulis* DC.); *(O. Engelmannia* Salm-Dyck); *(Condalia lycioides* (Gray) Web.); *(Ephedra* sp.); barberry *(Berberis trifoliolata* Moric); sumac *(Rhus microphylla* Engelm.); althorn *(Koberlinia spinosa* Succ.); Forbs include: *(Apodanthera undulata* Gray); *(Chenopodium* sp.); Devil's Claw *(Martynia parviflora* Wooton); *(Perezia* sp.); *(Chamaesyce* sp.); *(Kallstroemia parviflora* Norton); *(Amaranthus* sp.); (Cirsium sp.); *(Talinum aurantiacum* Engelm.); and *(Ibervillea tenuisecta* (Gray) Small). Grasses include: *(Hilaria mutica* (Buckl.) Benth.), *(H. belangeri* (Steud.) Nash), *(Panicum* sp.), and three awns *(Aristida* sp.).

MESQUITE-HUISACHE-BLACKBRUSH ASSOCIATION

The site taken as typical of this association is found near the Burford well in the southeastern corner of the Miller ranch, located on the fan from the Knox Canyon. There is a somewhat interfingering of porous and tighter soils which are responsible for the variety of species. Where the mesquites intermingle with the huisache there is more open stand of shrubs and greater grass coverage. The cover of grasses is very thin in portions bearing a predominance of huisache. Species found in the association include:

catclaw *(Acacia greggii* Gray), huisache *(Acacia constricta* Benth.), blackbrush *(Microrhamnus ericoides* Gray), mesquite *(Prosopis juliflora* (Swartz) DC.), althorn *(Koberlinia spinosa* Zucc.), sumac *(Rhus microphylla* Englm.), creosote bush *(Larrea tridentata* (DC.) Cav.), narrow-leafed yucca (Yucca elata Engelm.). *(Condalia lycioides* (Gray) Web.), barberry *(Berberis trifoliolata* Moric), *(Ephedra trifurca* Torr.), *(Krameria parviflora* Benth.), *(Ibervillea tenuisecta* (Gray) Small), *(Opuntia phaeacantha* Engelm.), *(O leptocaulis* DC.), *(Atriplex canescens* (Pursh) Nutt), *(Senecio longilobus* Benth.), *(Talinum aurantiacum* Engelm.). The grasses *(Hilaria mutica* (Buckl.) Benth.) and *(Bouteloua hirsuta* Lag.) varied in the percentage of cover from about 5 to 89 per cent according to the type and density of the shrub population.

YUCCA-BLACKBRUSH-GRAMA ASSOCIATION

The yucca-blackbrush-grama association occupies a limited area of the ranch. A heavier stand of yucca *(Yucca elata* Engelm.) with numerous clumps of blackbrush *(Microrhamnus ericoides* Gray) among the predominant grama grasses *(Bouteloua* sp.) characterize this association.

BLACKBRUSH-CREOSOTE BUSH ASSOCIATION

The blackbrush-creosote bush association is typified by the vegetation found on a hill along the road to Valentine, on the Roosevelt Ranch, approximately seven miles from the town of Valentine. The soil is rather porous, light colored gravels mixed with some boulders which are well rounded and containing a low ratio of finer sediments. This hill apparently was a submerged ridge in a fresh water lake during an earlier stage since many of the boulders are crusted with calcareous accumulations appearing to be worm tubes and algal in origin. The dominant creosote bush *(Laarea tridentata* (DC.) Cav.) and blackbrush *(Microrhamnus ericoides* Gray) are low and in open stands. Huisache *(Acacia constricta* Benth.) is next in abundance of the species. Allthorn *(Koberlinia spinosa* Zucc.), *(Ephedra* sp.), *(Echinocereus* sp.), *(Krameria parviflora* Benth.), and (*Yucca Torreyi* Shafer) are other shrubs present. The only forb found during the dry season was *(Ibervillea tenusisecta* (Gray) Small) which was twining about the allthorn bushes where it was protected from grazing by the various animals of the area. Only a few scattering sprigs of grasses, protected by the bushes, included three awns *(Aristida* sp.), grama *(Bouteloua* sp.), and *(Panicum* sp.). All grasses made up hardly more than a three to four percent cover.

ROUGHLAND LIFE BELT

The roughland life belt includes all the slopes of the Sierra Viejas above 5,000 feet which overlook the Valentine Plain. This designation is similar to that given in the Davis Mountains by Blair (1940:15). Six associations are recognized in this life belt. The lechuguilla-beargrass association occupies the major portion of the area, including the mesa top which has suffered least in the process of erosion, while the other five associations are on the more eroded portions of the slopes.

STREAM BED ASSOCIATION

The stream bed association includes the canyon floors. Boulders, gravels, and sands with very little soil afford only slight chance for vegetation to maintain roots. A 100 x 100 foot quadrat at the junction of Z.H. and Box canyons contained the following species: walnut *(Juglans rupestris* Engelm.) 24, catclaw *(Acacia greggi* A. Gray) 18, hackberry *(Celtis reticulata* Torr.) 9, *(Croton fruticulosus* Engelm.), *(Aloysia lycioides* Cham), *(Sapindus drummondii* Hook & Arn.)) 1, sumac *(Rhus microphylla* Engelm.), grape *(Vitis arizonica* Engelm.) 2. The forbs include *(Cassia lindheimeriana* Scheele), thistle *(Cirsium undulatum* (Nutt.) Spreng.), *(Eriogonum tenellum* Nutt.), *(Rhynchosia texana* Torr. & Gray), A*Rivina humilis* L.), and *(Alternanthera repens* O. Kuntze). Bluestem *(Andropogon* sp.), grama *(Bouteloua sp.)* and three-awns *(Aristida* sp.) together made up approximately five to ten percent grass cover in the quadrat.

Outside of the quadrat the vegetation varied according to the amount of available soil, moisture and exposure. Some of the species collected were: huisache *(Acacia constricta* Benth.), large toothed maple *(Acer grandidentatum* Nutt.), *(Carex hystricina* Muhl.), *(Chenopodium incanus* (Wats.) Heller), *(Eleocharis macrostachys* Britt.), *(Erythraea calycosa* Buckl.), ash *(Fraxinus velutina* Torr.), *(Juncus dudleyi* Weig.), *(J. torreyi* Cav.), *(Lythrum linearifolium* (Gray) Small), *(Matelea reticulata* (Engelm.) Woodson), *(Mimulus cordatus* Greene), *(Morus microphylla* Buckl.), *(Oenothera brachyptera* var. *wrightii* (Gray) Levl.), *(Phacelia integrifolia* var. *robusta* MacBr.), *(Polanisia uniglandulosa* (Cav.) DC.), *(Polygonum lapathafolium* L.), cottonwood *(Populus* sp.), plum *(Prunus virens* (Wooten & Standl.) Shreve), *(Psoralea tenuiflora* Pursh), gray oak *(Quercus grisea* Liebm.), willow *(Salix interior* var. *angustissima* Anders.), *(S. lasiolepis* Benth.), *(Siphonoglossa pilosella* (Nees) Torr.), *(Typha angustifolia* L.), *(Vernonia marginata* (Torr.) Raf.), *(Clematis Pitcheri* Torr & Gray) var. filifera (Benth.) Robinson).

The larger size of canyon species is probably due to the sheltered position in respect to both the sun and wind as suggested by Bray (1901) as well as to the greater amount of moisture coming from springs along the canyon walls.

CATCLAW-GRAMA ASSOCIATION

The catclaw-grama association covers most of the gentle canyon walls and slopes of the Sierra Viejas. The soil is largely derived from alluvial deposits such as volcanic ash and conglomerates laid down while a barrier existed across channels thereby producing lakes. This lake condition was later destroyed and the deposits have been eroded to a greater or less degree. A 100 x 100 foot quadrat near the old army fort, which is located in this association included the following: catclaw *(Acacia greggii* A. Gray) 43, mesquite *(Prosopis juliflora* (Swartz) DC.) 1, *(Aloysia lycioides* Cham.) 6, *(A. wrightii* (Gray) Heller), cedar *(Juniperus monosperma* (Engelm.) Sarg.) 3, *(Opuntia arborescens* Engelm.), *(O. Engelmannia* Salm-Dyck) 15, *(Yucca carnerosana* (Trel.) McKelvey) 2, *(Sapindus drummondii* Hook & Arn.) 1, *(Condalia lycioides* (Gray) Web.) 6, *(Baccharis* sp.). Among the forbs were *(Artemisia gnaphalodes* Nutt.), *(Talinum aurantiacum* Engelm.), *(Krameria parviflora* Benth.), *(Zinnia grandiiflora* Nutt.). Elsewhere on the slopes *(Celtis Pallida* Torr.), *(C. reticulata* Torr.), *(Quercus emoryi* Torr.), *(Q. grisea* Liebm.) are found. *(Commelina dianthifolia* Delile), *(Fallugia paradoxa* (Don.) Endl.), *(Gaura coccinea* Pursh), *(Larrea tridentata* (DC.) Coville), *(Lygodesmia juncea* (Pursh) D. Don.), *(Rhynchosia texana* Torr. & Gray) were also collected.

GRAMA-BLUESTEM ASSOCIATION

The grama-bluestem association occupies the slopes of the canyons which are south facing, in most instances. These slopes were covered with rock shingle from the underlying country rock. A limited amount of soil was found between the rocks. Most of the soil is washed away about as rapidly as it is formed. Some slopes were composed of volcanic ash where the canyon cut through old lacustrine deposits of this material. Of the various associations this one affords the best grazing (Carter 1931), but unfortunately the area is too limited to be of great value. Check quadrats were staked out on a slope having a forty-five degree angle. The following species were recognized: (*Ungnadia speciosa* Endl.), (*Opuntia Engelmannia* Salm-Dyck), (*O. Arborescens* Engelm.), (*Yucca torreyi* Shafer), (*Tecoma stans* (L) H.B.K.), (*Agave lechuguilla* Torr.), (*Fouquieria splendens* Engelm.), (*Echinocereus* sp.), (*Aloysia wrightii* (Gray) Heller), (*Acacia greggii* A. Gray), (*Asclepias* sp.), (*Croton* sp.), (*Sida neomexicana* Gray), (*Commelina dianthifolia* Delile), (*Bouteloua hirsuta* Lag.), (*Andropogon* sp.) and three-awns (*Aristida* sp.). In places the grass cover amounts to about 80%, however there are areas of rock talus slides interspersed on which there is practically no cover.

ROCK BLUFF ASSOCIATION

Steep rocky declivities have been designated the rock bluff association. Relatively little vegetation exists on these bluffs, however the few species present may be larger in size than is attained on some other areas. This is probably due to the more moderate insolation on the north facing slopes and to the greater amount of water available as seepage from the slopes above. Columnar jointed igneous deposits weather away to leave almost vertical walls which allow entry of the root systems. The Mexican buckeye (*Ungnadia speciosa* Endl.), cedar (*Juniperus monosperma* (Engelm.) Sarg.), (*Croton fruticulosus* Engelm.), Arizona grape (*Vitis arizonica* Engelm.), bedstraw (*Galium wrightii* Gray), (*Bouvardia ternifolia* (Cav.) Schlecht) are characteristic of the association.

HUISACHE-LECHUGUILLA ACCOCIATION

Fairly close stands of lechuguilla (*Agave lechuguilla* Torr.) and huisache (*Acacia constricta* Benth.) interspersed with scattering blackbrush (*Microrhamnus ericoides* Gray) clumps and various spherical cacti characterize the huisache-lechuguilla association. The soil on which this association is found was apparently derived from volcanic ash which later became infiltrated with caliche. Grass cover is less than one per cent, hence the areas of this association are of little value as range. The lechuguilla is the outstanding succulent of the region and would probably overrun greater areas were it not for the partial destruction of the species by pocket gophers (*Thomomys bottae*).

LECHUGHILLA-BEARGRASS ASSOCIATION

The major portion of the more gentle slopes of the range has been assigned to the lechuguilla-beargrass association. The upper slopes get greater amounts of precipitation, due to the fact that over fifty per cent comes during the late summer and early fall plus a high degree of insolation with low relative humidity the vegetation is of small size. The succulent lechuguilla *(Agave lechuguilla* Torr.) and beargrass *(Nolina texana* Wats.) predominate the scene. Dwarfed forms of acacia, sumac and various cylindrical and spherical cacti are found. Forbs include *(Amaranthus retroflexus* L.), *(Asclepias* sp.), *(Cirsium ochrocentrum* Gray), (*Dichondra argentea* Willd), *(Dyssodia thurberi* (Gray) Wats.), *(Gaura coccinea* Pursh), *(Linum aristatum* Engelm.), *(Lygodesmia texana* (Torr & Gray) Greene), *(Solanum rostratum* Dunal), *(Tragia nepetaefolia* Cav.), and (*Zinnia grandiflora* Nutt). Grasses include bluestem *(Andropogon* sp.) three awns *(Aristida* sp.), grama *(Bouteloua curtipendula* (Michx.) Torr.), *(B.* sp.), *(Hilaria belangeri* (Steud) Nash.), and panic grasses *(Panicum* sp.)

RIO GRANDE BASIN BIOTIC DISTRICT

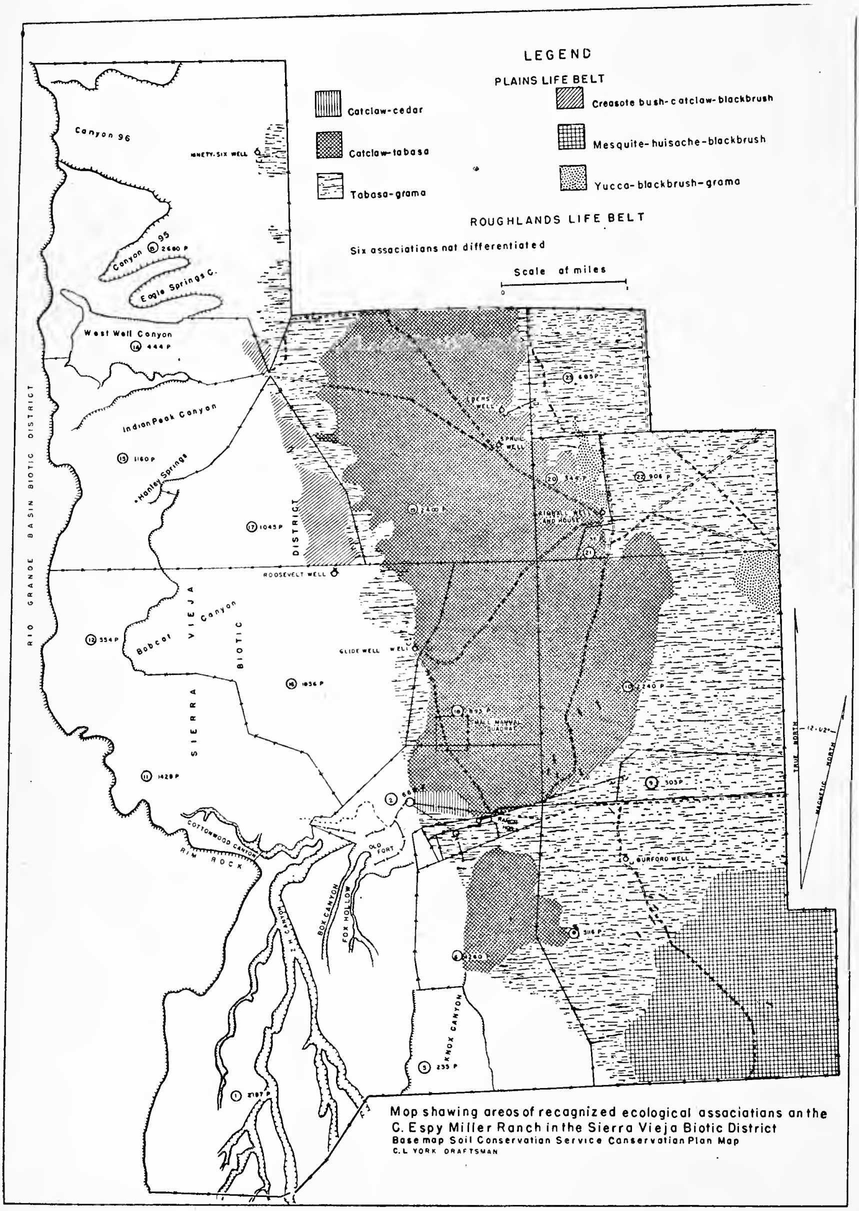
The Rio Grande basin biotic district may be divided into two major divisions. The first is the area subject to inundation when the river is in flood stage and the second the upland not subject to floods. The river bottom soil, referred to the Gila series by Carter (1931), is very fertile, and is used for agricultural purposes from time to time. Three associations have been recognized in this area: the salt cedar-mesquite along the river channel and arroyos; the old field association on fallow fields and the cottonwood association, principally on the Mexican side of the stream, but also present in spots on the American side. Species collected from the flood plain include: *(Ammocodon chenopoides* (A. Gray) Small), *(Amaranthus* sp.), (*Aster spinosus* Benth.), *(Baccharis glutinosa* Pers.), *(Boerhaavia intermedia* Jones), *(Chamaesyce glyptosperma* (Engelm.) Small), *(Encelia frutescens* Gray), *(Helianthus ciliaris* DC.), *(Heliotropium curassavicum* L.), (*Hoffmanseggia densiflora* Benth.), *(Kallstroemia parviflora* Norton), *(Lycium torreyi* Gray), *(Pectis paposa* Har. & Gray), *(Populus wislizeni* (Wats.) Sarg.), *(Portulacca retusa* L.), *(Prosopis juliflora* (Swartz) DC.), (*Prosopis odorata* Torr. & Frem.), *(Phyla nodiflora* (L.) Greene), *(Salsola pestifer* A. Nels.), *(Solanum elaegnifolium* S. Wats.), *(Tamarix galica* L.), (*Tidestromia languginosa* (Nutt.) Standl.), *(Trianthema portulacastrum* L.), *(Trichloris mendocina* (Phil.) Kuntze, and *(Ximinisia encelioides* Cav.)

The uplands consist of remnants of an old eroded lake bed. Precipitation in this area is limited and insolation is very intense, producing a marked desert vegetation. The gravelly hills comprise the ocotilla-creosote bush association and the intervening valleys the catclaw-creosote bush association. Species obtained from these associations include *(Aloysia wrightii* (Gray) Heller), *(Bahia dealbata* Gray), *(Boerhaavia intermedia* Jones, (*Bouteloua trifida* Thunb.), *(Calliandra eriophylla* Benth.), *(Coldenia Greggii* A. Gray), *(Croton corymbulosus* Engelm.), *(Ibervillea tenuisecta* (A. Gray) Small), *(Japtropha spathulata* (Oct.) Muell. Arg.), *(Kallstroemia grandiflora* Torr.), *(K. parviflora* Norton), *(Krameria parviflora* Benth.), (*Krynitzkia albida* (H.B.K.) Jolmot), *(Lycium puberulum* Gray), *(Menodora scabra* (Gray), and *(Tetraclea angustifolia* Wooton & Standl.).

SUMMARY

A field party with Dr. W. Frank Blair, Director, investigated the vertebrate populations and related ecological aspects of the Sierra Vieja Mountains during June and early July 1948. This range of mountains parallels the Rio Grande in Presidio and Jeff Davis Counties for about 40 miles. Faulting of volcanic deposits of late Cretaceous and Early Tertiary

age during Mid-Tertiary brought the range into being. To the west lies the Rio Grande plain composed of eroded lacustrine deposits. To the east is the Valentine plain occupying an inland drainage basin. Precipitation at the foot of the range averages about 14.5 inches annually. Higher on the slopes rainfall is no doubt somewhat greater. Low relative humidity with high insolation account for the sparseness and small size of the vegetation of the plains and exposed slopes. Within the canyons and on sheltered, north



Map showing areas of recognized ecological associations on the C. Espy Miller Ranch in the Sierra Vieja Biotic District
Base map Soil Conservation Service Conservation Plan Map
C. L. YORK DRAFTSMAN

Fig. 1

facing slopes humidity and insolation are suitable to the vegetation of greater size. Rainfall at the Miller ranch is greater than at Presidio, which is to the south and is less than at Alpine or Balmorrhea which are to the northeast. Over fifty percent of the precipitation occurs during late summer. The frost free period is about 225 days on the average.

Within the Sierra Vieja region of the Chihuahuan biotic province two biotic districts are recognized, namely the Sierra Vieja and the Rio Grande Basin. The former is divided into the Plains life felt and the Roughland life belt, while the Rio Grande Basin is divided into the Flood-plain and Upland life belts. Seven associations are recognized in the Plains life belt and six in the Roughland life belt. Three associations are recognized within the Rio Grande Flood-plain and two on the hills of the Upland belt.

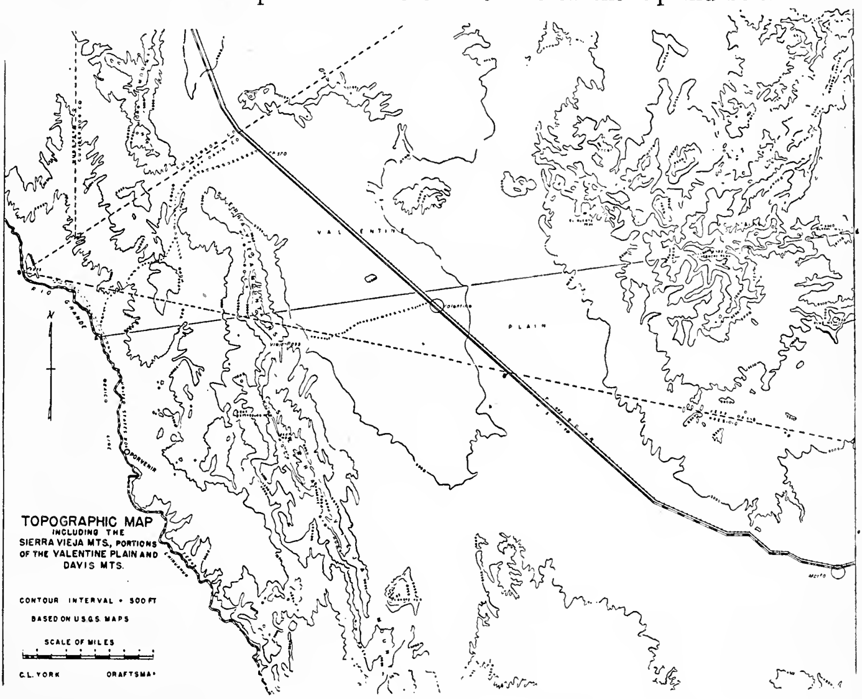


Fig. 2

Editor's note:

Through an error in composition the two maps accompanying this paper were included in Jameson, D. L. and A. G. Fleury—1949—Reptiles and amphibians of the Sierra Vieja. Tex. J. Sci. v(2): 54-79. Our editorial apologies are made for the mistake. The maps were Mr. York's and should be so credited.

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SHELLED MOLLUSKS OF THE TEXAS COAST FROM GALVESTON TO PORT ARANSAS

T. E. Pulley
Department of Biology, University of Houston
Houston, Texas

The need for a comprehensive study of the fauna of the Texas coast has long been felt, and a simple check list of the species likely to be encountered would be a valuable addition to the literature. Most of the studies that have been made apply principally to the Atlantic coast with only vague references to species extending westward into the Gulf of Mexico.

In the following table of Mollusks in the collection at the University of Houston, less than half of the species are actually listed in the current, and readily available, literature as occurring in Texas. In many cases the published range may be interpreted as including Texas, but in others, such as *Modiollus demissus,* Texas apparently represents a range extension of at least several hundred miles.

In addition to the 75 classified species in the collection, there are 10 species which have not been identified. Each collecting trip produces new species for the collection, so the list is far from complete. The identification of some species is tentative, but all are being checked by Dr. William J. Clench of the Museum of Comparative Zoology, Harvard University.

The implication of this study is that much basic information is lacking with respect to the marine biology of the Texas coast. A suggestion for the improvement of this situation would be a correlated effort on the part of all the schools or other institutions in the area to publish brief descriptive lists of each of the major faunal groups. Such lists need not be complete or extensive at the present time, but the mere fact of their publication would undoubtedly stimulate further investigations.

NAME	COMMON NAME	OCCURRENCE	PUBLISHED RANGE
1. *Acmaea candeans* Orbigny	Limpet	Common on jetties Galveston and Rockport	Fla. - W. Indies
Anachis avara translirata Ravenel	Greedy anachis	Common in Aransas Bay	No. Car. - Fla. Keys, Gulf of Mexico
Architectonica granulata Lamarck	Granulated Sundial	Occasional Galveston and Matagorda Island	No. Car. - W. Indies
Bulla occidentalis Adams	Western bubble	1 specimen Aransas Bay	Fla. to Texas and W. Indies
Busycon perversum Linne	Left handed whelk Lightning shell	Occasional Galveston, Matagorda and Mustang Islands	No. Car. to Cuba, Gulf of Mex.
Busycon pyrum Lillwyn	Fig Shell	Same as above	Cape Hatteras to Gulf of Mex.
Cantharus cancellari Conrad	Cross barred spindle	Scarce. Galveston	So. Car. to Tex.
Cerithidea pliculosa Menke	Horn shell	Scarce. Aransas Bay	La., Tex. and W. Indies
Crepidula fornicata Linne	Boat shell	Occasional Galveston, Matagorda and Mustang Islands	Nova Scotia to Tex.
Crepidula plana Say	Flat slipper shell	Common throughout, stuck to other shells	Nova Scotia to Tex.
Diodora cayensis Lamarck	Little keyhole limpet	1 specimen. Aransas Bay	Chesapeake Bay to Fla.
Fasciolaria tulipa Linne	Tulip shell	Scarce. Galveston, Aransas Bay, Matagorda Island	No. Car. to W. Indies
Janthina globosa Swainson	Globe violet snail	Scarce. Matagorda Island	Fla. and most warm seas. Gulf stream

NAME	COMMON NAME	OCCURRENCE	PUBLISHED RANGE
Janthina janthina Linne	Violet snail	Occasional after storms. Galveston and Matagorda Islands	Same as above
Littorina irrorata Say	Lined periwinkle	Common on reeds in salt marshes	Mass. to Gulf of Mex.
Littorina ziczac Gmelin	Zebra periwinkle	Common on jetties Galveston and Rockport	Fla. and W. Indies, Tex.
Murex fulvescens Sowerby	Spine ribbed murex	Scarce. Galveston and Matagorda Islands	No. Car., Fla. and Tex.
Oliva sayana Ravenel	Lettered Olive	Scarce. Galveston, Matagorda and Mustang Islands	No. Car. to Tex.
Phalium granulatum Born	Scotch bonnet	Scarce. Matagorda Island	Cape Hatteras to Tex.
Polinices duplicata Say	Moon shell	Common throughout	Maine to Gulf of Mex.
Thais haemostoma floridana *Sinum perspectivum*	Ear shell	Common throughout	New Jersey to W. Indies
Say *Strombus pugilis*	Fighting conch	1 specimen. Galveston	Fla. to Tex., W. Indies
Linne Conrad	Florida rock shell	Common on oyster reefs	No. Car., W. Indies, Tex.
Vermicularia spirata Philippi	Worm shell	Scarce. Lydia Ann Channel, Aransas Pass	Mass. to W. Indies Tex.
Abra aequalis Say		1 specimen. Lydia Ann Channel	Conn to Fla., Tex.
Anatina canaliculata Say	Channeled duck	Common throughout	Maryland to Brazil

NAME	COMMON NAME	OCCURRENCE	PUBLISHED RANGE
Anatina lineata Say	Lined duck	1 specimen. Matagorda Island	New Jersey to Texas, Brazil
Anomia simplex Orbigny	Plain jingle shell	Common Matagorda Island and Aransas Bay	Nova Scotia to W. Indies
Arca incongrua Say	White ark	Common throughout	No. Car. to Tex.
Arca campechiensis Gmelin	Bloody clam	Common throughout	Mass. to Tex.
Arca secticostata Reeve	Cut ribbed ark	1 specimen. Matagorda Island	No. Car., Fla., Tex.
Arca transversa Say	Transverse ark	Common throughout	Mass. to Key West
Arca umbonata Lamarck	Mossy ark	Scarce. Galveston and Matagorda Islands	No. Car. to Gulf of Mex.
Atrina rigida Lillwyn	Stiff sea pen	Occasional throughout	No. Car. to South America
Atrina serrata Sowerby	Saw toothed pen	Same as above	No. Car. to W. Indies
Larnea costata Linne	Angel's wing	Common throughout	Mass. to W. Indies
Cardita floridana Conrad	Bird shell	Occasional Matagorda and Mustang Islands Aransas Bay	Fla. to Tex.
Chione cancellata Linne	Cross barred venus	Rare. Galveston. Common Matagorda & Mustang Islands	No. Car. to Brazil
Chione latilirata Conrad	Broad ribbed venus	Occasional Galveston, Matagorda & Mustang Islands	Southern Fla. and W. Indies

NAME	COMMON NAME	OCCURRENCE	PUBLISHED RANGE
Dinocardium robustum Solander	Large cockle	Occasional throughout	No. Car. to Brazil
Donax variabilis Say	Variable wedge	Common throughout	No. Car. to Mex. and W. Indies
Dosinia discus Reeve	Disk dosinia	Occasional throughout	New Jersey to Mex.
Echinochama arcinella Linne	Spiny chama Chest rock oyster	Rare. Galveston and Matagorda Islands	No. Car. to W. Indies
Laevicardium mortoni Conrad	Morton's cockle	2 specimens. Lydia Ann channel	Nova Scotia to Brazil
Lithophaga bisulcata Orbigny	Two furrowed date	Occ. in oyster shell Lydia Ann channel	No. Car. to Gulf Mex., W. Indies
Loripinus schrammi Crosse		3 specimens. Matagorda Island and Lydia Ann channel	No. Car. to Mex.
Lucina floridana Conrad	Jamaica lucina Florida lucina	Rare. Galveston and Hustang Islands	West Fla. to Tex.
Lucina jamaicaensis Lamarck		Rare. Galveston. Common. Aransas Bay	Fla. to W. Indies, Uruguay
Macoma constricta Brugierre		Occ. Galv., Mustang and Matagorda Islands	No. Car. to Brazil
Martesia caribaea Orbigny		Common in oysters, Lydia Ann channel	New York to Fla., Texas and Cuba
Modiolus demissus Dillwyn		Common in bank Greens Lake. Galvez. West Bay	Virginia to Fla.
Modiolus tulipus Linne	Tulip mussel	1 specimen. Matagorda Island	No. Car. to W. Indies
Mytilus exustus Linne	Scorched mussel	Common on jetties Rockport	No. Car. to Tex., W. Indies

NAME	COMMON NAME	OCCURRENCE	PUBLISHED RANGE
Mytilus recurvus Rafinesque	Curved mussel	Common throughout on oyster shells	Rhode Island to Texas, W. Indies
Mulinia lateralis Say	Little surf clam	Common throughout	New Brunswick to Texas, W. Indies
Noetia ponderosa Say	Ponderous ark	Common Galveston. Occassional further south	Mass to Fla. and Tex.
Nuculana acuta Conrad	Pointed nut shell	1 specimen. Aransas Bay	Mass. to W. Indies
Pecten gibbus amplicostatus Dall	Scallop	Common throughout	Tex. to Colombia
Ostrea cristata Born	Crested oyster	Rare. Lydia Ann channel	Tampa, Fla. to W. Indies
Ostrea virginica Gmelin	Virginia oyster	Common throughout	Maine to Fla. W. Indies, Gulf Mex.
Periploma angulifera Philippi	Angulated spoon shell	Rare. Galveston. Common. Matagorda Island	Ga. to Fla and Tex.
Petricola pholadiformis Lamarck	False Angel's wing	Occasional Galveston	Maine to W. Indies
Pholas camprechiensis Gmelin	Campreche wing	Rare Galveston	No. Car. to Central America
Rangia cuneata Gray	Wedge rangia	Common in bays	Ga., Fla., Gulf of Mex.
Semele profica Pulteney	Rayed semele	Occ. Galveston, Matagorda and Matagorda Islands	Va. to Gulf of Mex. and W. Indies
Spisula solidissima similis Say	Surf clam	Occasional Galveston	Mass. to Fla. and Gulf of Mex.
Tagelus divisus Spengler		Occasional Aransas Bay	Mass. to Fla. and Tex.

NAME	COMMON NAME	PUBLISHED RANGE	OCCURRENCE
Tagelus gibbus Spengler	Stout razor clam	Common throughout	Mass. to Fla. and Tex.
Tellidora Cristata Recluz		1 specimen. Lydia Ann channel	West Fla. to W. Indies
Tellina alternata Say	Rose petal	Common throughout	No. Car. to Gulf of Mex.
Tellina lineata Turton	Rosy Tellina	1 specimen. Lydia Ann channel	Fla., W. Indies, Brazil
Trachycardium muricatum Linne	Common cockle	Occasional throughout	No. Car. to W. Indies
Venus campechiensis Gmelin	Round clam	Occasional throughout	Chesapeake Bay to Cuba, Tex., Yucatan
Dentalium texasfanum Philippi	Tooth shell	Scarce. Lydia Ann channel	No. Car., West Fla., La., and Tex.
Spirula spirula Linne	Squid	Occasional Galveston and Matagorda Islands	Mass to tropics in open sea

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EARLY PLANT COLLECTIONS RETURN TO TEXAS

Lloyd H. Shinners
Herbarium
Southern Methodist University, Dallas

A herbarium is the means by which the plant life of a large area is sampled and made conveniently accessible for study. Texas, with the largest area and one of the most varied floras of the United States, is botanically one of the most poorly known. Although its botanical exploration has been going on for more than a hundred and twenty-five years (it began in the summer of 1820, when Edwin James, surgeon of Major Long's expedition to the Rocky Mountains, collected a few plants along the Canadian River in the Texas Panhandle), the early collections were sent elsewhere, and are not readily available for study by resident botanists. Pioneer collectors were either sent from Europe, or were patronized by botanists in the older parts of the United States. Not until the late 1890's did a Texas institution begin serious study of the flora of the state. Just fifty years ago, W. L. Bray made collections more or less incidentally to ecological studies of the vegetation. These were the earliest collections to remain permanently in Texas, and were the beginning of what is now the largest herbarium in the state, that of the University of Texas. An important addition was one of the sets distributed from the Missouri Botanical Garden in 1907, including 652 specimens collected in south-central Texas by Ferdinand Lindheimer from 1849 to 1852. Collections made by S. M. Tracy in Texas and other Gulf states in the early 1900's became the nucleus of the Tracy Herbarium of the A. & M. College of Texas.

The very old collections made in Texas were often fragmentary or lack full or reliable data, or have had labels lost or mixed up (sometimes deliberately) in handling. It must be admitted that at present many are of little more than sentimental historical value. Recent intensive activity directed toward the building up of herbaria in the state has resulted in the accumulation of material for taxonomic, geographic, and morphological study far superior to what was once available. But the original collections of new species, the "type collections," are necessary for comparison if names are to be correctly applied. Old collections record the presence of species in areas from which they have now disappeared, or may indicate the former geographic limits of native plants which have turned weedy and spread, or record the first appearance of foreign weeds. For certain purposes, old collections have a value out of all proportion to their number or quality.

During the past few years, Southern Methodist University has been fortunate enough to secure a number of early Texas plant collections, dating as far back as 1839. The University Herbarium, though the youngest and at present the third largest in the state (it dates from 1944, and now contains 30,000 specimens of flowering plants), thus becomes the one with the oldest specimens. These are from two sources. In 1945, a lot of 633 specimens in the Herbarium of the Milwaukee Public Museum was generously made available in exchange by Albert M. Fuller, Curator of Botany. These were chiefly from the herbarium of Emil Dapprich, a German teacher who visited Texas in 1873, obtained specimens of Lindheimer and Charles

Wright, later lived in Milwaukee, and ultimately left his collections to the Public Museum there. In 1948, in excess of 1,000 specimens were received by special arrangement with Dr. Robert E. Woodson, Jr., Curator of the Herbarium of the Missouri Botanical Garden, St. Louis. These include both mounted and unmounted duplicates of collections made by several botanists in Texas and other northern states during the last century. Chiefly responsible for their acquisition by the Missouri Botanical Garden were George Engelmann, whose private collections (including a large number of Lindheimer's from Texas) became an important initial part of the Garden's Herbarium, and William Trelease, the Garden's first director, who sought to make his institution the leading center of botanical study for the Southwest. In the late 1890's and early 1900's, the Garden purchased nearly all the available Texas collections (the largest being that of Julien Reverchon, first resident botanist of Dallas, very few of whose specimens have been distributed), and subsidized collectors to carry on additional exploration. As a result, there are now probably more Texas specimens to be found at the Missouri Botanical Garden than at any one institution in Texas.

The early plant collections which have been mounted and are now available for use in the Herbarium of Southern Methodist University are tabulated below. Altogether, slightly less than 1,400 early Texas specimens are now on hand; others are still to be received. The plant families most amply represented are the *Gramineae, Leguminosae, Euphorbiaceae,* and *Asclepiadaceae*. There are a number of isotypes in the collections of Lindheimer, Wright, Reverchon, and Heller, of species described by Engelmann, Gray, Bush, and Heller.

Collector	*No. of Sheets*	*Dates*	*Counties*
Ferdinand Lindheimer	ca. 330	1839-1852	Austin, Comal, Galveston, Harris
Charles Wright	97	1850-1852	El Paso (chiefly), Hays or Travis
Emil Dapprich	ca. 200	1873-?	Comal, Dallas, Mason
J. F. Joor	23	1875-1884	Anderson, Cherokee, Galveston, Harris, Lampasas, Travis, Washington
F. Rauterberg	ca. 25	1888	Comal
Julien Reverchon	315	1876-1905	Brazos, Brown, Burnet, Culberson, Dallas, Frio, Kaufman, Llano, Navarro, Oldham, Palo Pinto, Potter, Smith, Van Zandt, Wood, Young
Gustav Jermy	2	1899-?	Gillespie
G. C. Nealley	1	1893	Duval
A. A. Heller	177	1894	Kerr, Nueces, San Patricio
S. M. Tracy	49	1902	Galveston, Howard, Mitchell, Parker
C. T. Brues	ca. 25	1911	Grayson, Travis

ACCLIMATIZATION OF A MARINE FREE-LIVING CILIATE (OXYTRICHIDAE) TO LOWER OSMOTC PRESSURE *

Robert Anigstein **
Ball High School, Galveston, Texas †

Protozoa have fascinated me ever since I first studied them in my high school biology course. To think, a watch glass can contain hundreds of active, living organisms, each of which can perform all the functions of life of higher animals, though it consists of but a single cell! Even more wonderful is the fact that from a form similar to present day protozoa, all life on earth originated.

Living on an island in the Gulf of Mexico presented an excellent opportunity for studying the protozoan marine fauna. Furthermore, having been granted the privilege of using the laboratory facilities of the University of Texas Medical Branch, I also had the benefit of consultation with some members of its staff.

After studying Richard R. Kudo's "Protozoology" and having acquired general knowledge of microscopic animals, I began looking for a problem worthy of investigation. Since the salt concentration of a partially enclosed body of seawater, such as Galveston Bay, would vary in different seasons, it was of interest to explore to what extent seawater protozoa can be acclimatized to lower salt concentrations under laboratory conditions. No study of this type could be found in the available literature, though Loefer (1938) studied the acclimatization of freshwater protozoa to higher osmotic pressure.

MATERIAL AND METHODS

Water samples taken from promising locations along the northeast shore of Galveston Island gave origin to five wild cultures of protozoa. The entire cultures were studied under wide-field microscope for several weeks and samples examined under high power. Most of the cultures abounded in various species of protozoa. Distilled water was then added to one of the cultures with the result that 2 weeks later most of its protozoa were killed. However, a large, elongated yellowish ciliate, about 200 to 250 microns long, was among the survivors and found in large numbers on the bottom of the dish. Since this form, which was later identified as belonging to the family *Oxytrichidae*, seemed more resistant to sudden changes in osmotic pressure, it was decided to use it as object of the present study (Fig. 1).

In order to duplicate natural conditions as closely as possible, seawater from the locality of the original cultures was used as the medium throughout the experiments. This was analyzed by evaporating a measured

* Presented before the State meeting of the Junior Academy of Science, December, 1948.
** Winner of A. A. A. S. Honorary Junior Membership, 1949.
Winner of a Westinghouse Science Scholarship in the nationwide Science Talent Search, 1949.
Winner of the Bausch and Lomb Honorary Science Award, 1949.
Winner of a 1949 University National Scholarship.
† Present address: Cornell University, College of Arts & Sciences, Ithaca, New York

Fig. 1. Magnification appr. 300 ×

quantity to complete dryness in an oven and weighing the residual substance. It was found to contain 39 grams of dissolved minerals per liter.

A culture of the ciliates which contained very few other protozoa was established by transferring about twenty specimens to a Petri dish containing stock seawater and a sufficient amount of algae to support the organisms. The latter were transferred by a capillary blunted pipette—a most convenient instrument for handling the ciliates.

Prior to acclimatization experiments, it seemed desirable to learn the rate at which this ciliate reproduces under normal conditions. The procedure consisted in transferring a drop of water containing one ciliate and a small amount of algae from the stock culture into the hollow of a ground depression slide, which was then sealed with a coverslip. This preparation was examined daily under the microscope, and as soon as a completed division was observed, one of the offspring was transferred to another, similar slide.

The procedure for the acclimatization experiments was as follows: (1) samples of the stock seawater were diluted with distilled water to the desired concentration; (2) the required number of clean, dry watch glasses were weighed; (3) ten ciliates were transferred from the stock culture to each of the watch glasses; (4) diluted seawater (0.5 ml.) was then added plus one drop of specially prepared algae infusion (100 mg. pulverized algae in 5 ml. stock seawater) to provide a uniform and adequate food supply. The watch glasses were weighed again, and the weight of the added media was determined. Since the salt concentration of the medium is raised by seawater carried over from the stock culture of ciliates as well as by that in the algal infusion, the following formula was derived to determine the amount of distilled water to be added in order to bring the culture back to the desired salt concentration:

$$\frac{A - .5\,[1 + c\,(g - 1)]}{g} \cdot \frac{1 - c}{c}$$

A total weight of liquid in watch glass
c desired concentration of medium
g specific gravity of the stock seawater, gravimetrically determined and equal to 1.0244.

After this procedure was completed, the cultures were sealed with greased coverslips, placed in semi-darkness, and counted periodically.

EXPERIMENTAL RESULTS

In the reproductive rate experiments, a total of 30 generations exhibited an average rate of one division every 24 hours in fresh medium, and once every 32 hours in a medium one month old. Two series of acclimatization experiments were performed. In the first, 5 cultures were prepared in seawater concentrations of 30, 50, 64, 80 and 100 percent respectively, the last being the control. The latter was thought necessary since some of the ciliates die from handling with a pipette. Cultures were observed for 4 days, at the end of which period 10 ciliates were transferred from each of dilute seawater cultures to preparations with the original 100% seawater. These new cultures were under observation for 7 days (Fig. 2).

The second series involved 7 cultures, in 10, 20, 40, 60, 80 and 100 percent seawater respectively. They were under observation for 4 days, whereupon several ciliates from each culture were transferred to pure distilled water; all the ciliates died shortly.

The accompanying table I and graph (Fig. 2) show the reproductive rates of the ciliates in different seawater concentrations. With the exception of one culture, ciliates in concentration above 50% seawater multiply at much the same rate as the ones in the parallel control cultures. The ciliates transferred to 50% seawater reproduce very rapidly for the first day or two after transfer; then the rate drops. At 30% the rate was high for the first 2 days, after which reproduction temporarily ceased. Ciliates surviving the transfer to 40% seawater began to multiply after the third day, at nearly the rate of the controls. A very slow reproduction was noticed in 10% preparations, while no multiplication was noticed in the 20% seawater. In the latter medium a marked inhibition of motility was noted the day following the transfer, the ciliates becoming almost motionless by the third day. Simultaneously they become shorter, almost round and lighter in color; their body being spread out in the manner of an amoeba. A reexamination of the culture on the 12th day revealed all ciliates dead, although other cultures were alive. The ciliates in the 10% culture suffered a slight inhibition in motility and some deformation. On the 12th day several specimens were transferred back to 100% seawater with the result that all died immediately, whereas ciliates from 40 and 50 percent seawater survived the transfer.

CONCLUSIONS

(1) The species of Oxytrichidae under study will tolerate a wide range of osmotic pressures. Although some ciliates will survive a direct transfer to a medium one tenth of the original salt concentration, a high mortality rate, inhibition of motility and decrease in reproductive rate as well as deformation were observed at concentrations below 30%.

(2) The organisms will survive transfer from seawater concentrations of 30 to 80 percent back to the original medium after being 4 days in the former. On the other hand, ciliates transferred from 10% seawater will not survive the change.

(3) The critical concentration to which the cilates are transferable is approximately 30% seawater. Their reproduction is hampered 2 days after transfer to this concentration, although movement is not affected and the ciliates will survive the return to the original medium.

(4) The reproduction rate of the ciliates transferred to 50% or less seawater is stimulated temporarily, but the rate decreases after 2 days. Rates are not greatly affected by transfer to seawater concentrations above 50%.

(5) Though a varying mortality rate will occur when the ciliates are first returned from dilute media to the original 100% seawater, reproduction soon returns to normal.

(6) The species under study could not be sufficiently acclimatized to lowered salt concentrations to survive a direct transfer to distilled water.

(7) The reproductive rate of one isolated ciliate is higher than that of a mass culture.

(8) Old medium inhibits reproduction. This finding is contrary to observations of Dimitrova and Johnson and Hardin (Hall, 1941).

Since the scope of this study was limited and only a small number of

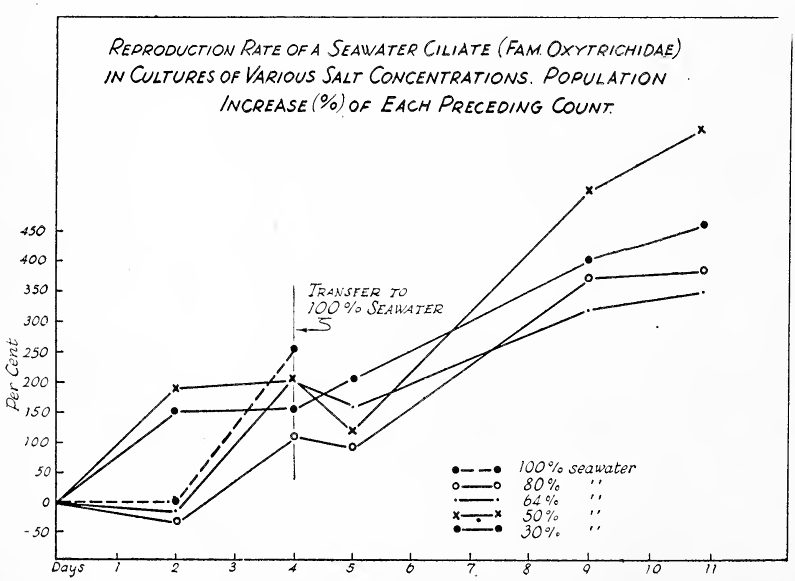

Fig. 2

Table I

RATIO OF REPRODUCTION OF CILIATES TRANSFERRED TO DILUTE SEAWATER

DAYS	1			2			3			4		
Seawater conc.	No. ciliates		Ratio	No. ciliates		Ratio	No. ciliates		Ratio	No. ciliates		Ratio
in percent	Contr.	Exp.	E/C	Contr.	Exp.	E/C	Contr.	Exp.	E/C	Contr.	Exp.	E/C
10	9	4	.44	—	—	—	50	7	.31	—	—	—
20	9	5	.55	—	—	—	50	5	.18	—	—	—
30	—	—	—	10	25	2.5	—	—	—	35	25	.29
40	9	5	.55	—	—	—	50	24	.86	—	—	—
50	9	14	1.56	—	—	—	50	37	.47	—	—	—
50	—	—	—	10	28	2.8	—	—	—	35	35	.36
60	9	12	1.33	—	—	—	50	50	.75	—	—	—
60	—	—	—	10	8	.8	—	—	—	35	26	.93
80	9	14	1.56	—	—	—	discontinued			—	—	—
80	—	—	—	10	7	.7	—	—	—	35	17	.69

experiments were performed, the conclusions are tentative only. Further investigation of this problem should prove an interesting contribution to experimental protozoology, particularly to the responses of a living cell to its environment.

ACKNOWLEDGEMENT

I wish to express my gratitude to the staff of the University of Texas Medical School, especially to the members of the Department of Preventive Medicine for the invaluable advice and assistance given me in carrying out this project.

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MICRO-ORGANISMS IN BEERMETERS

J. N. Stern
University of Nuevo Leon
Monterrey, Mexico

Beermeters belong in many countries to the standard equipment of a brewery.

The apparatus is of much utility to the national treasury in simplifying the tax problems, and it is an important tool of the brewmaster, which helps control the efficiency of the factory and permits an exact calculation of the ratio between the raw materials and the end product.

On the other hand, the chief drawback of the beermeter lies in the danger of contamination and bacterial infection which can easily interfere with the standard quality of beer if the meter is not kept in a state of immaculate cleanliness.

The word contamination in relation to an industrial fermentation like the production of beer has two meanings. The first one is the presence of any organism which does not belong in the normal process without any consideration as to whether or not it can spoil the product, and the second is contamination with definite bacteria and fungi able to produce alterations in the wort or beer, causing the so-called "beer diseases." It is easy to understand, then, that in practice attention is directed primarily to the second form of infection, the only one which is important to the brewmaster.

As a rule the biological control in breweries is limited to organisms which can live and thrive during the process of brewing or in the end product.

The present paper deals with a few examinations of the microflora in beermeters. The determination of bacteria was limited to twelve genera, using Shimwell's method. However, all of the fungi were reported.

The beermeters were made by Bowser, and had been in use, without opening, for as much as six months, mounted in a room with a temperature of O°C (32°F), and washed by reflux several times in a week.

The microflora was isolated from a residue which could be found by opening the apparatus in three or four places, where probably the liquid, if not stagnant, flows slowly. The identifications were made by routine media, like Lindner's cell, isolation in Petri dishes, spore formation of yeasts on gypsum blocks, different stainings, etc.

The results obtained were as follows:

BEER METER NO. 1 contained spores of *Bacillus subtilis,* but they were very scarce, as were *Lactobacillus* sp., *Aerobacter* sp., *Flavobacterium proteus, Torula* (a wild yeast not belonging to the genus *Saccharomyces) Aspergillus* sp., and *Sachsia* sp. Present in fair numbers fere *Acetobacter* sp., *Saccharomyces cerevisiae, Saccharomyces* sp. (a wild yeast of the *exiguus* type), and a fungus *Pullularia pullulans.* A wild yeast *Mycoderma* sp. (not belonging to the genus *Saccharomyces)* was present in fair numbers.

BEER METER NO. 2 contained *Micrococcus* sp., but it was very scarce, as were *Lactobacillus* sp., *Aerobacter* sp., *Flavobacterium* sp., the spores of *Clostridium* sp., and fungi of the genera *Oidium* sp., *Rhizopus* sp., *Aspergillus* sp., and *Sachsia* sp. Present in fair number were *Acetobacter* sp., *Mycoderma* sp. and the fungus *Pullularia pullulans. Saccharomyces cerevisiae* and another member of the same genus (a wild yeast of the *exiguus* type) were abundant.

BEER METER NO. 3 contained *Micrococcus* sp., *Aerobacter* sp., spores of *Clostridium* sp., *Lactobacillus* sp., *Flavobacterium* sp., and the fungi *Oidium* sp., *Rhizopus* sp., *Sachsia* and *Alternaria,* all very scarce. *Acetobacter* sp. and *Mycoderma* (a wild yeast not belonging to the genus *Saccharomyces)* occurred in fair numbers, while *Saccharomyces cerevisiae,* and another member of the same genus (a wild yeast of the *exiguus* type) and the fungus *Pullullaria pullulans,* were abundant.

None of the following were found: *Propionibacterium* sp., *Sarcina* sp., *Streptococcus* sp., *Escherichia* sp., *Achromobacter* sp.

These experiments make evident the fact that beermeters present a potential danger of infection if the apparatus is not kept in a state of absolute cleanliness, which cannot be obtained by reflux washing. The meters must be opened frequently in order to keep them clean, and only the responsible brewmaster is able to fix in each case the time between the intervals.

If the beer is not pasteurized this cleanliness must be enforced.

Summary:

(1) In the beermeters can be found a residue composed mostly of living cells.

(2) The formation of the residue is due probably to a stagnation of the fluid in certain points of the apparatus.

(3) Most of the organisms belong to *Sacch. cerevisiae,* but still there are others which present a potential danger of the infection for the end product.

(4) To avoid danger, the meter must be kept in a state of immaculate cleanliness, which can be obtained only by opening the apparatus at frequent intervals. If the beer is not pasteurized such cleanliness must be enforced.

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APPLICATION OF SOME BIOGENETIC LAWS TO STRATIGRAPHY

A. A. L. Mathews
Department of Geology
University of Houston

The paper presents the biogenetic laws without analysis. Emphasis is placed on the laws applicable to the fossils which serve as a guide for stratigraphic units, without listing the innumerable forms. Fragmental parts of senescent fossils can be ued satifactorily for stratigraphic determinations.

The application of biogenetic laws to stratigraphy is based upon a common interpretation that skeletal characters reflect the living viscus of the organism. Since our only available data for the analysis of pre-existing life are the exhumed skeletons of that life, the application of biogenetic laws is based on the careful and detailed study of fossils. Close study of fossils reveals the laws to be as applicable to the living-past as they are to the living-present.

Granted that fossils establish the type and character of the living organisms, the problem of this thesis is to outline certain characteristics in reference to stratigraphic sequence, and apply only specific biogenetic laws to those organisms involved. To perform this task properly, it is necessary to trace one character at a time through a great series of generations and note the changes in the character from time to time. By tracing the development of the straight conch of the Cephalopoda, this principle can be illustrated. Straight shells with simple sutures are taken as primitive characters of the Nautiloidea (Ordovician). The last of the primitive straight forms occur in the Triassic. A straight conch Cephalopoda occurs in the Upper Cretaceous, but is a member of the Ammonoidea with complex sutures. In comparing these two groups, the ontogenetic pattern appears somewhat reversed; i.e., as far as shape of shell is concerned, the Ordovician *Michelinoceras* (formerly *Othoceras)* looks like the Upper Cretaceous *Baculites*. But, in the ontogeny of the former the straight conch persists throughout life, while the conch in *Baculites* in the early stages is coiled and straightens after the fifth volution in the adult stage of growth, with complex sutures superimposed on it. The biogenetic laws involved are Nos. 20 and 21; "When a race has run its course, the senile species of the group tend to re-establish themselves by reverting to a primitive characteristic of the group," "When such reversions take place, the more recently acquired characters will be superimposed on the primitive character to which the group reverts." This sudden appearance of the straight conch in *Baculites* might be considered by some as mutation. It is more properly considered reversion, since the 22nd law states; "There is no positive record of saltation (mutation) in paleontological data." The straight conch Cephalopoda with simple sutures is restricted almost entirely to Paleozoic sediments; the straight conch Cephalopoda, with complex sutures, is restricted more narrowly to the Upper Cretaceous.

All biogenetic laws should have stratigraphic significance. To make a practical application of this theme, one must be a detailed student of a phyletic group, and further, must appreciate the value of detailed stratigraphy. The late Doctors Stuart Weller and James Perrine Smith more nearly typify this specialized type of student in their studies of the Brachiopoda and the Cephalopoda, respectively. Each man believed implicitly in the 9th biogenetic law; "Ontogeny recapitulates phylogeny." Dr. Weller could observe a fragment of some brachiopods and not only tell the species, but also the section in the formation whence it was obtained. Dr. Smith's observations and analyses were even keener. Today we realize that there is no limit to the application of the law of recapitulation. It is universal and almost axiomatic.

Any student of paleontology is startled when he realizes that in the composition of early Cambrian faunas, the remains of the highest developed invertebrates outnumber all other forms two to one. This is true not only in number, but also in the number of species. Why? To answer this involves a thorough understanding of animal life and the application of biogenetic laws to it. Law No. 4 states; "As life forms progress, differentiation of body parts become necessary." This is true of the Trilobita, which represented the Arthropoda in Cambrian time. The trilobites were the most muscular organisms of that time. Muscles require points of attachments. When the mineral composition of the sea reached the proper constituency, the trilobites were covered with an exoskeleton of chiton, forming body segments and jointed appendages.

Analytical study of early Cambrian trilobites proves that the phylum was highly developed and greatly deployed at the beginning. An interpretation states that the life span of the phylum had become senescent, i.e., had reached phyletic senility. This is illustrated by *Olenellus gilberti,* and others. In other words, the members of the group as a whole, living in the Cambrian seas, were on the downward slope of the bell-shaped curve. See law No. 10.

As a result of this condition, trilobites are highly desirable for use as guide fossils for detailed stratigraphic differentiation in the study of early Paleozoic formations. To illustrate, *Nevadia weeksi* is limited to the lowest Cambrian formations. It was an end-form, and did not give rise to another group of trilobites like those of Mesinacus, of a later date. Law No. 16 states; "Phylagerontic (phyletic senescent) groups can not give rise to new groups." From this discussion, one must conclude that later trilobites were derived from a primitive stock which may not have been preserved as a fossil, or if preserved, have not been discovered or recognized.

Law No. 15 states: "Extreme variation within a group is evidence of group senility." This is verified by the fact, that, almost from the beginning in the Lower Cambrian, there were great numbers of aberrant trilobites which are known either by loss of body parts, like *Agnosus;* by extreme ornamentation, like *Zacanthoides,* and *Certocephala;* and, in formations of later ages, like those extremely bizarre senescent genera, *Trochurus, Echinolicas, Terataspis* and *Ondontocephalus,* all in the Onondaga of Devonian age, or, by extreme plainness and large size, like *Illaenus* and *Bumastus* of the

Chazy Group in the Ordovician. In both cases all of the genera had a short life and have been found in rock beds of very narrow stratigraphic range.

Law No. 18 states; "When a group actually loses a character it does not reappear in a later group." For instance, the eye base of early Cambrian trilobites is an elevated, elongated, lunar-shaped protruberance on the cheek, such as are found in *Olenellus,* and others. Whereas, the eye base of the Middle Cambrian and later trilobites is much reduced in length and increased in convexity, such as are found in *Paradoxides, Olenius, Isotelus, Phacops* and others. This limitation in the development of a single part of a fossil makes it possible for the student to determine the age of the rocks by a single fragment of trilobite, if the eye base is included. The same analysis holds for the genal spines, glabell, free cheek, etc.

The application of these laws is illustrated by the more senile fossil groups, such as the Pelmatozoa, Brachiopoda, Cephalopoda, Ostracoda and Insecta. Some progressive invertebrate groups such as the Gastropoda and Pelecypoda, are good only for long range deductions.

The early brachiopods found in Cambrian rocks are considered simple progressive forms. As far as the shells are concerned, this is true, but the animals inhabiting the shells were senile. The innumerable species of brachipods which developed during Paleozoic time were the result of bi-lateral branching of the more primitive. Traces of the primitive stock can be found in Upper Cambrian and later rocks, and one stock, at least, comprises the dominant brachipod species living today. This is due to the (?) 5th biogenetic law; "Primitive characteristics are the most persistent in phyletic groups." This means that the primitive forms are durable. This law is illustrated by *Lingula* and its allies; also, *Natica* which served as a radical stock for all coiled Gastropoda, even *Fusus* and its allies.

Contrast, for instance Lingulacea with the Productidae. The Productidae appeared suddenly in late Devonion rocks as a senile group, reached their maximum deployment quickly in the Mississippian and Pennsylvanian and became extinct in the Permian. The spines of the early productids were solid, but the spines of the latter were hollow. Thus, during the short span of geologic history, the Productidae became species of great specialization and short life. Thus, these fossils are most useful for stratigraphic differentiation. This illustrates law No. 15; "Extreme variation within a group is evidence of group senility." Schuchert states that the Productidae were derived out of Kutorginidae through Suchertinidae and Billingsellidae, but it gave rise to no new groups, illustrating again the 16th law; "Phylagerontic (phyletic senile) groups can not give rise to new groups."

The application of this thesis to stratigraphy is as follows: the specific characters are so exact that a student can tell a species and stratigraphic range by a single fragment of the fossil, like a spine base of a productid, such as the spine base of *Productus cora,* a species limited to the lower part of middle Pennsylvanian. One of the hollow spines of the old *Productus subhorrida* will determine the Rex Chert of the Permian.

This paper merely suggests the application of the thesis to the practical use of any of the phyletic groups when properly analyzed and applied to stratigraphy. This point of view is important, since the great mass of field data which must be used for determining the age of strata contain only fragments of the included fossils. Therefore, this approach to the study for biostratigraphy should be included for a clear and exact training for field work.

The biogenetic laws are presented for ready reference. There is probably no limitation to the amount of illustrative data that can be presented.

SOME BIOGENETIC LAWS

1. All living substances originate from some pre-existing living substance, except the probable original primitive protoplasmic mass which is supposed to have been formed from inorganic compounds.
2. There is a gradual change from one individual to another individual, i.e., from parent to offspring. (a) Under constant conditions, the change is most gradual in primitive groups and most rapid in senile groups. (b) Under adverse conditions, the change is still most gradual in primitive groups, yet more rapid than under constant conditions, and, the senile groups tend to die out.
3. All life is built up from individual cells, in unicellular as well as in multicellular organisms. In the Metazoa, cells are differentiated and arranged into tissues to form differential structures.
4. As life-forms progress differentiation of body parts become necessary.
5. Primitive characteristics are the most persistent in a phyletic group.
6. Only selective basic and necessary characteristics are carried over from one phyletic group to another phyletic group in the orderly development and progression of life-forms.
7. Induced characters are advanced in the ontogeny of all subsequent generations, thus, accelerated. These are highly accelerated in derived genetic groups.
8. An acclereated character may become completely submerged or lost in the ontogeny of the N-th descendant.
9. Ontogeny recapitulates phylogeny.
10. The life span of a group forms a bell-shaped curve.
11. Phyletic variation in point of number of individuals and species form a bell-shaped curve.
12. Regeneration is a character in the Metazoa derived and modified from primitive binary fission, perhaps, of the Protozoa.
13. The power of regeneration is submerged or lost in advanced groups due to high specialization.
14. Submerged characters of the primitive group may reappear suddenly in the ontogeny of a higher group.
15. Extreme variation within a group is evidence of group senescence.
16. Phylogerontic (phyletically senescent) groups cannot give rise to new groups.
17. Actual loss of body parts is an indication of degeneracy.
18. When a group actually loses a character it does not appear in a higher group.
19. Severe climatic changes of world-wide dimensions tend to destroy phylogerontic (phyletic senescen) groups and to establish new groups.
20. When a race span has run, the aberrant species of the group tend to revert back to some primitive characteristic of the group.
21. When such reversion takes place, the more recently acquired characters will be superimposed on the primitive characters to which the group reverts.
22. There is no positive record of saltation in paleontologic data.

MEASURING INSTRUMENTS AND THEIR USE

Arthur E. Lockenvitz
Associate Professor of Physics
The University of Texas

Radioactive substances give off three kinds of radiation, namely alpha, beta and gamma rays. Radioactive measurements are chiefly concerned with the measurements of the properties of these rays and the effects they produce. In addition to the above radiations there are some secondary radiations such as neutrons, neutrinoes and mesotrons which play an important role in radioactive technics.

The alphas and betas may be detected directly by virtue of their charge provided they are present with sufficient intensity. Otherwise their detection depends on their ability to ionize the matter with which they interact. All the other radiations are detected by the ionization which they produce directly or indirectly in their interaction with matter.

The instruments used to detect or measure the intensity of radioactive radiations may be classed as follows: 1. Electroscopes. 2. Electrometers with ionization chambers. 3. Ionization chambers with vacuum tube amplifiers. 4. Proportional counters. 5. Geiger-Mueller counters. 6. Cloud chambers. 7. Photographic plates. 8. Scintillation screens. 9. Crystal counters.

Which of these instruments is the most desirable depends on numerous factors, such as the particular kind of radiation to be measured, the intensity of the radiation, the time available for making an observation, the nature of the information desired from the measurement, the cost of the equipment compared to the time involved in taking data, etc.

The oldest of these instruments, the thin metal (gold leaf) electroscope, is as sensitive as any of the more refined and elaborate devices. It consists essentially of a capacity made up of the leaf system and the case. The gravitational force on the leaf gives the restoring force and the electrostatic forces between leaf and its surroundings furnish the displacing forces. The voltage sensitivity of such a system may be expressed in divisions motion of the leaf per unit change in the potential of the leaf. Since

$Q = CV$, $dQ = CdV$ and $S = \frac{dX}{dV}$ therefore, $S = \frac{CdX}{dQ}$; and the charge

$$\text{sensitivity} = \frac{dX}{dQ} = \frac{S.}{C}$$

Here Q = charge on electroscope
V = Voltage across electroscope capacity
X = Deflection of leaf
S = Voltage sensitivity
$\frac{dX}{dQ}$ = Charge sensitivity.

As an example, suppose an electroscope has a voltage sensitivity of $\frac{1 \text{ div.}}{\text{volt}}$ a capacity of 10 $\mu\mu f$ and a volume of 100 cc. The residual or background ionization is of the order of 6 ion pairs per cc. per second. In the 100 cc. there would be formed

$$100 \times 6 \times 1.6 \times 10^{-19} \frac{\text{coulombs}}{\text{sec}} = 10^{-16} \frac{\text{coulombs}}{\text{sec}}$$

$$x = \frac{1 \text{ div x } 10^{-16}}{10^{-11} \text{ Farad volt}} \frac{\text{coulombs}}{\text{sec}} = \frac{10^{-5} \text{ div}}{\text{sec}}$$

or 1 div. in 10^5 sec., that is, in a little over a day. If, therefore, observations were made with such an instrument on a radioactive source, it would be possible to detect ionization of the order of cosmic ray intensity, provided observations were made over a period of about a day.

Electrometers are in reality much refined electroscopes. In general they may be classed into two groups, the moving string or fiber and the moving vane. The voltage sensitivities range from about that used in the electroscope example above to about 10,000 times that amount. The capacities, with the ionization chambers attached, are of the same order of magnitude as that of the electroscopes. Therefore in general it is possible to make the same measurements in a corresponding shorter time.

Because of the ratio of inertia to restoring force of the moving system it is quite possible that the natural period $T = 2\Pi\sqrt{\frac{m}{K}}$ or $T = 2\Pi\sqrt{\frac{I}{K}}$ may be appreciable for a sensitive instrument. Electrometer periods may run from the order of .01 sec. to 100 seconds in practice, the longer periods being in general associated with the greater sensitivities.

Ionization chambers consist of two electrodes generally in an enclosed space. The region between the electrodes is filled with an appropriate gas. A potential difference is applied between the electrodes; in series with the e.m.f. and the condenser, formed by the electrodes, is a current measuring device, Fig. 1.

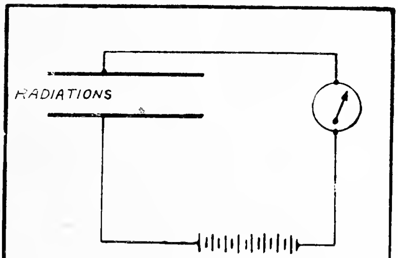

FIGURE 1

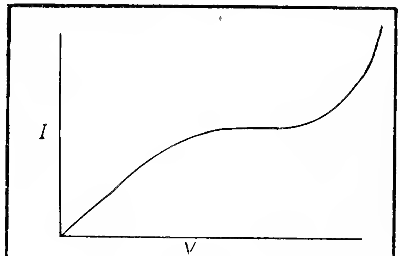

FIGURE 2

The radiation entering the gas between the electrodes ionizes this region proportional to the intensity of the radiation. The flow of these ions in the circuit, condenser, battery and current measuring device constitutes a current. Fig. 2 shows the relation between current and applied e.m.f.

For a given constant rate of ionization the current at first rises more or less linearly with the voltage across the chamber until a region is reached where the current is quite constant and independent of the voltage. This is the region in which the ionization chamber is used. At much higher voltages the current again rises with increased voltages and this is the region in which ionization by collision takes place. At very high voltages an electrical breakdown of the gas occurs.

Strong radioactive sources may produce sufficient ionization so that the ionization current can be measured with a sensitive D'Arsonval gavanometer. For example, a polonium alpha particle source of .01 millicuries emits 3.7×10^5 alpha particles per second and each alpha particle produces about 1.6×10^5 ion pairs. Therefore the ionization current would be $3.7 \times 10^5 \times 1.6 \times 10^5 \times 1.6 \times 10^{-19} \frac{\text{coulombs}}{\text{sec.}} = 9.47 \times 10^{-9}$ amp $= 10^{-8}$ amp approximately. Gamma and beta rays produce much less ionization than alpha rays and except for the most intense sources, electrometers or vacuum tube amplifiers of the inverse feed back type must be used to measure the weak currents. It is possible with these devices to measure currents of the order of 10^{-14} amp without real difficulty, and with sufficient care and patience it is possible to push this down by a factor of 10 or 100.

Ionization chambers, proportional counters and Geiger-Mueller counters all have certain characteristics in common. They all have a condenser with a potential difference across it, and the dielectric of the condenser is a gas which is ionized by the radiation to be detected or measured. The chief differences lie in the voltage applied to the electrodes, the electric circuit used for detecting the current and to a less extent on the shape of the electrodes and the nature of the gas between the electrodes.

Fig. 3 shows the relation between pulse size and applied voltage.

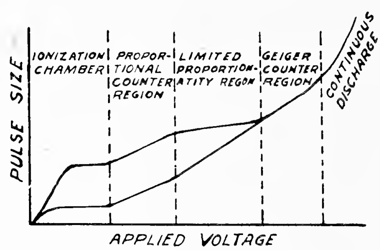

FIGURE 3

All three devices can in principle measure individual particles coming into the chamber. When used as an ionization chamber the current flowing in the chamber circuit is due only to the primary ions formed directly or indirectly by the incoming particle. The proportional region makes use of the fact that the primary ions can form new ions from the gas if the electric field is high enough. Over a certain region of field strength the amplification is quite linear with field strength; here the current pulse with a fixed voltage is linear with the number of primary ions formed.

In the Geiger region the pulse size no longer depends on the extent of the primary ionization.

The cloud chamber is most useful in certain studies. Here use is made of the fact that a super cooled vapor will condense on ions. In fact, with a proper selection of the amount of super cooling, it is possible to select to some extent the type or ion which serves as a nucleus for the condensation. Super cooling is produced by suddenly expanding the volume of a vapor. This is usually done by having a mixture of gas and vapor in a cylinder with a movable piston. Radiations passing through this cylinder ionize the mixture of gas and vapor. If the piston is then suddenly moved to increase the volume a cooling takes place and the vapor condenses in droplets on each ion. Thus liquid drops mark out the path of the incoming radiation. Alpha particles are very strong ionizers and will leave a dense thick track of droplets. Beta particles are much less effective as ionizers and leave a thin track. Gamma rays produce little ionization directly, but the photoelectrons which they release from the gas will ionize the gas and thus the photoelectron tracks will reveal the path of the gamma rays.

All three of the radioactive radiations will affect the photographic plate. With sufficiently intense radiations the general blackening will serve as a measure of the intensity of the radiation.

Alpha particles and other heavy charged particles can produce sufficient energetic photographic action to be detected as individual particles. They leave tracks in the photographic emulsion much the same in character as the tracks they leave in cloud chambers, but very much shorter. These tracks must be observed and measured under a high power microscope.

Many minerals fluoresce under the action of radiations. Therefore screens made of these materials can be used for the detection of the radiations. In general the radiations must be quite intense in order to produce sufficient fluorescence to be detected by the eye. Individual alpha particles will produce sufficient fluorescence to be detected by the well rested eye. The fluorescent flashes due to the individual particles are known as scintillations, and scintillation screens are very useful tools for detecting and measuring even extremely weak alpha sources. Recently electron multiplier tubes have been used to replace the eye for detecting the scintillations.

Certain crystals such as the diamond when placed between suitable electrodes and connected to proper circuits will act in much the same way as Geiger-Mueller counter tubes. These crystal counters are still in a study and development stage, but it appears as though they already can replace with some advantage the regular Geiger-Mueller counters in some applications.

The electrical circuitry which is associated with radiation measurements has grown tremendously in complexity during the last forty years.

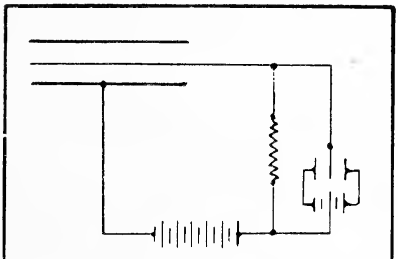

FIGURE 4

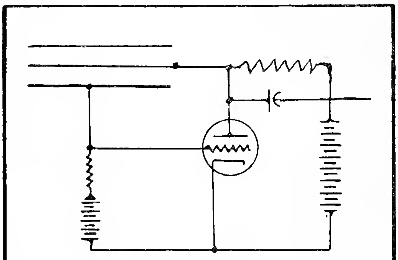

FIGURE 5

Fig. 4 shows an elementary counting circuit using a string electrometer to register the counts. The counting speed of such a circuit is quite low. A number of arrangements have been devised using vacuum tube circuits to extinguish the discharge and thus increase the counting speed. Fig. 5 shows one such arrangement.

For strong radioactive sources the number of counts per second may be too high for mechanical recording or counting. In this case circuits are devised to transmit only a definite fraction of the impulses delivered by the Geiger counter tube. The so-called scale-of-two circuit is used to halve the number of pulses. Fig. 6 shows one such arrangement. If two scale-of-two

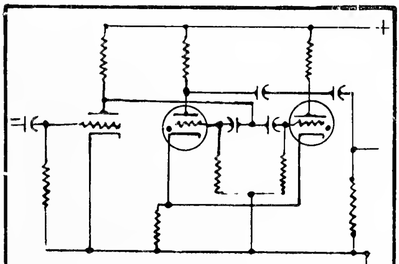

FIGURE 6

circuits are put in tandem only ¼ of the original count will come through and the combination would form a scale of 4. In this way scale factors of 2, 4, 8, 16, 32, 64, etc. can be built up.

Fig. 7 shows a multivibrator quenching circuit which performs the function of Fig. 5 and in addition assures that the pulses coming out are more equal in size.

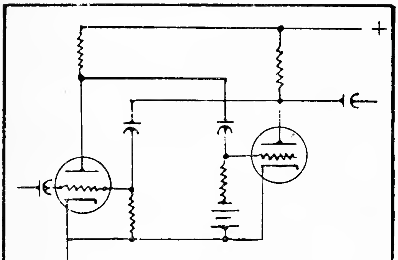

FIGURE 7

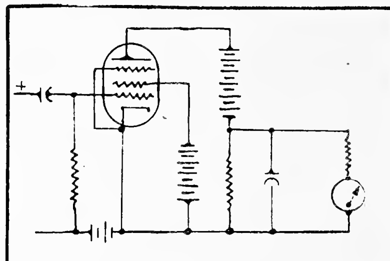

FIGURE 8

If the circuit in Fig. 8 is fed by the output of the multivibrator circuit, the RC circuit of Fig. 8 will integrate the current pulses and thus cause the output meter to give a steady reading proportional to the rate at which the pulses are received. Such an arrangement is known as a rate meter.

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A NEW THERMODYNAMIC CRITERION AT THE CRITICAL POINT OF MATTER

by R. Plank and L. Riedel
Institute of Technology
Karlsruhe, Germany

INTRODUCTION

Since the first beginning of Thermodynamics much care was applied to find a legitimate relation between the pressures and temperatures of a saturated liquid in equilibrium with its vapor. Such a relation would enable one to predict pressure-temperature values of a substance, for which only a few experimental data have been collected. An investigation into the very extensive work done in this field of research leads to the conclusion that all fundamental knowledge was already present in the classical period of thermodynamics and that nothing of real importance has been added later.

The basis of all semi-empirical pressure-temperature formulas is the equation of Clausius and Clapeyron

$$L = T\ (v_g - v_f) \frac{dP}{dT} \quad . \quad . \quad . \quad . \quad (1)$$

where L is the latent heat of vaporization, v_g and v_f the volumes of saturated vapor and of boiling liquid, P the pressure and T the absolute temperature.

With a series of well known approximations equation (1) leads to a pressure-temperature formula of the kind

$$\log_e P = A - B/T + C \log_e T + DT + ET^2 + FT^3 + \quad . \ . \ . \ . \quad (2)$$

For a comparatively small region the two terms A − B/T may suffice, but to represent the pressure temperature curve within large limits of P and T including the critical point at least four terms on the right side of equation (2) should be applied and the coefficients must be adapted to corresponding experimental values of P and T. The lack of real knowledge in this field precludes any statement as to which terms should be added if a higher degree of accuracy is desired; the number of coefficients should of course remain as low as possible. In the literature besides the terms A − B/T very often $C \log_e T + DT$ is found, but not seldom $C \log e_e T$ is omited and $DT + ET^2$ is given preference; sometimes even more terms of the series of equation (2) are added. If the results of accurate measurement of pressure and temperature of a substance are compared with values calculated by means of a formula of type (2), we mostly find a perfect coincidence at such points, which have been chosen for the determination of coeffcients A, B, C . . . , but between these points quite big systematic deviations from the measured values occur. This indicates that equation (2) is not best adapted to represent the results of such measurement.

Much more complicated equations, including a great number of constants, have been proposed to cover exactly a large set of experimental values. We may mention the equations proposed for steam at the Bureau of Standards:

1) by Osborne, Stimson, Fiock and Ginnings (2)

$$T \log P = aT + b + cx^3 + dx^5 + ex^6 \quad . \ . \ . \ . \ . \ . \quad (2a)$$

$$\text{where } x = \frac{T^2}{298{,}000} - 1$$

2) by Osborne and Meyers (3)

$$\log P = A + \frac{B}{T} + \frac{Cx}{T}(10^{Dx^2} - 1) + E(10^{Fy^5/4}) \quad . \ . \ . \quad (2b)$$

$$\text{where } x = T^2 - 293{,}700 \text{ and } y = 374.11\text{-}t$$
$$t = T - 273.16$$

Obviously it is important to find an equation which is equally able to reproduce the course of the derivative dp/dT. So it is advisable to analyze first this derivative function.

THE LOGARITHMIC DERIVATIVE OF THE PRESSURE-TEMPERATURE FUNCTION

We suggest to introduce instead of dP/dT the logarithmic derivative

$$\alpha = \frac{d \log P}{d \log T} = \frac{T}{P}\frac{dP}{dT} \quad . \quad . \quad . \quad . \quad (3)$$

which we shall call α, and which is dimensionless. Therefore one could expect that α, following the law of corresponding states, should be for all substances a universal function of the reduced temperature $\delta = T/T_c$. (The subscript c always refers to the critical state). The magnitude α has a definite physical meaning, as we can easily find from equation (1):

$$\alpha = \frac{L}{P(v_g - v_f)} = \frac{L}{W}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

W being the external work done in the course of vaporization. So α is the ratio of the total to the external energy of vaporization.

Using the subscript 1 for the normal boiling point (at 1 Atm) and neglecting in equation (4) the value of v_f at this normal boiling temperature T_1, assuming further that v_{g1} can approximately be expressed in terms of the law of a perfect gas, we recognize that α_1 stands in a close relation to the molar entropy of vaporization L_1/T_1. Following the rule of Trouton this ratio has for normal substances a value of 21 and therefore

$$\alpha_1 = \frac{L_1}{RT^1} = 10.6 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where R = 1.986 is the universal gas constant. As the reduced normal boiling temperature $\delta_1 = T_1/T_c$ has nearly the same value of 0.64 for all normal substances it follows that the universal value α_1 is in conformity with the law of corresponding states. This law requires also a universal value of α_c which really was found to be approximately equal to 7 for many non-associating substances.

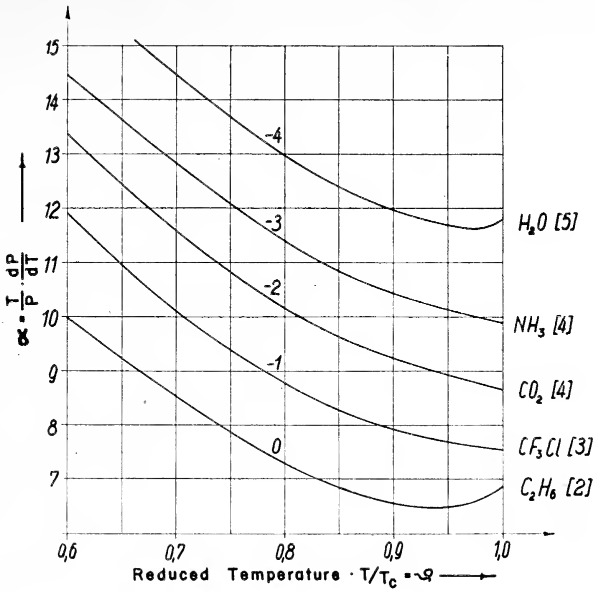
Whilst these considerations are well known and have been used widely, it seems that the course of α_c as a function of temperature has never been thoroughly analysed. This is strange, as this course certainly influences decisively the pressure-temperature relation. Bertrand (1) working on thermodynamic tables for different substances proposed the formula $1/\alpha = aT - b$, in which a and b are constants, and he found that for many substances b = 0.02. On the other hand one can derive from equation (2):

$$\alpha = B/T + C + DT + 2\,ET^2 + 3\,FT^3 + \quad . \quad . \quad . \quad . \quad (6)$$

With the first two terms on the right α becomes a hyperbolic function of T, but if we add more terms this function is considerably changed. To find the real course of α as a function of temperature we should base on extensive experimental results.

THE NEW CRITERION

The course of the curve $\alpha = f$ (T) can easily be determined for a number of substances, for which vapor tables up to the critical point have been prepared. In Figure 1 some of such curves are shown. Reduced temperatures $\delta = T/T_c$ have been chosen as abscissae to enable for the different curves a comparison based on the law of corresponding states. As all these curves would nearly coincide, they have been separated from each other in Figure 1 by displacing the scale of ordinates by one unit for each curve.



The course of these curves becomes very striking in the vicinity of the critical temperature $\delta = 1$. Whilst for $CClF_3$, CO_2 and NH_3 the values of a decrease continuously approaching the critical point (the amount of decrease becoming less and less), we find for C_2H_6 and H_2O a minimum of a slightly below the critical temperature. As the law of corresponding states suggests a universal course of the a-curves, it seems most improbable that these curves may show such drastic distinctions for different substances. It seems more probable that such deviations are caused by some small experimental errors or by the use of a non-appropriate empirical formula. The course of the a-curves for $CClF_3$, CO_2 and NH_3 indicates indeed the existence of a minimum value as well, but it would be reached for these substances slightly beyond the critical temperature, thus having no real meaning.

It suggests itself to assume the existence of a law, which was not clearly perceived until now, and which we like to express in the following hypothesis:

a as a function of temperature has a minimum at the critical point.

The mathematical formulation is

$$\left(\frac{da}{dT}\right)_c = O \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

This is an essential statement as to the behavior of the pressure-temperature curve near the critical point. Differentiating equation (3) and using the new criterion (7) we find the following expression for the second derivative of the pressure-temperature curve at the critical point:

$$\left(\frac{d^2P}{dT^2}\right)_c = a_c\,(a_c - 1)\,\frac{P_c}{T_c^{\,2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

or in reduced values $\Pi = P/P_c$ and $\delta = T/T_c$

$$\left(\frac{d^2\Pi}{d\,\delta^2}\right)_c = a_c\,(a_c -)\;.\;.\;.\;.\;.\;.\;. \qquad (8a)$$

As for most normal substances a_c equals about 7, we find for most substance for $\left(\frac{d^2\Pi}{d\delta^2}\right)_c$ a value of about 42.

TESTING THE NEW CRITERION WITH EMPIRICAL PRESSURE-TEMPERATURE FORMULAS

As may be seen from equation (8) the new criterion means a statement as to the second derivative of the pressure-temperature curve in the vicinity of the critical point. But it is well known that if we represent a measured quantity as a function, small experimental errors are very much increased in the values of the first derivative. Thus equation (2b) representing with extreme accuracy the measurements on steam performed at the Bureau of Standards gives a value P = 217.96 Atm. at t = 374° C in the immediate neighborhood of the critical point. Another equally exact equation elaborated by Smith, Keyes and Gerry (4)

$$\log \frac{P_c}{P} = \frac{x}{T}\;\frac{(a+bx+cx^3+ex^4)}{1+dx}\;.\;.\;.\;.\;.\;. \qquad (2c)$$

where $x = T_c - T$, gives a value P = 217.88 Atm. at the same temperature t = 374° C. The deviation of the two pressure values is less than 0.05%. But if the derivative dP/dT is determinated using both equations at this temperature we find a deviation of more than 1.4%, equation (2b) giving 2.6307 Atm/degree, whilst equation (2c) gives 2.59376. It is obvious that much greater deviations must be expected in the values of the second derivative. Even the most exact empirical formulas are not fit for testing the validity of the new criterion. Another test based on measured values of the heat of vaporization L and of the volumes v_g and v_f using equation (1) is still less appropriate as it introduces new uncertainties, and means a real detour.

Applying some of the well known empirical pressure-temperature equations and differentiating them twice it is not difficult to calculate the temperature for which a becomes a minimum. If equation (7) is valid, this temperature should coincide with the critical temperature. Or one can calculate from the empirical pressure-temperature equation values of $(d^2P/dT^2)_c$ and of a_c and control whether these values are consistent with equation (8). But one cannot expect very much from all these tests, as all conventional pressure-temperature equations are not exact enough to allow the calculation of the second derivative function, and are not set up with a special consideration of the critical region. The result of a great number of such tests could neither prove nor disaprove the new hypothesis. Quite many empirical formulas show a minimum of a far away from the critical point. But as generally the deviations are not too great and of different signs, for different substances, one can admit that they are due to a non-sufficiently high degree of accuracy of the equation. Let us restrict ourselves to two examples:

The pressure-temperature-curve of $CClF_3$ was represented by L. Riedel

(5) in the range from −139° C up to the critical point t_c = +28.8° C by the equation

$$\log P = 7.8172 - \frac{1109.12}{T} - 0.014127T + 0.1883 \times 10^{-4} T^2;$$

with this equation a minimum of α is reached not at the critical temperature of 302° K but at the higher temperature of 328° K. This corresponds with the α-curve for this substance represented in Fig. 1, and based on this equation. With α_c = 6.542 and P_c = 38.1 Atm we find in equation (8) $\alpha_c(\alpha_c - 1)P_c/T_c^2$ = 0.0152 Atm°/K² and $(d^2P/dT^2)_c$ = 0.0141 Atm/°K². This last value is 7% smaller.

For carbon dioxide Meyers and Van Dusen (6) expressed the pressure-temperature curve between the triple point T_{tr} = 216.5° K and the critical point T_c = 304.2° K. by the equation

$$\log \frac{P_c}{P} = \frac{x}{T} (a+bx+cx^2+dx^3+ex^4)$$

where $x = T_c - T$ and the constants have the values a = 2.98426, b = -6.22982×10^{-3}, c = 1.05784×10^{-4}, d = 9.21483×10^{-7} and e = 3.72320×10^{-9}. From this equation we find α_c = 6.872, $\alpha_c(\alpha_c-1)P_c/T_c^2$ = 0.0318 Atm/°K² and $(d^2P/dT^2)_c$ = 0.0333 Atm/°K². This last value is here 4.5% too high.

The only substance for which we have very accurate (and very complicated) pressure-temperature equations is water. We shall treat this substance separately in paragraph 6.

As it is seen that empirical pressure-temperature equations do not present a sound basis for testing the new criterion, we shall now try to perform such a test by the immediate use of experimental values employing a suitable method of calculation.

TESTING THE NEW CRITERION WITH THE IMMEDIATE USE OF MEASURED VAPOR PRESSURES

The method employed for a great number of substances to check the validity of the new criterion is as follows:

The measured values (P_1, T_1) and (P_2, T_2) of two neighboring points on the pressure-temperature curve are used to form the ratio.

$$\alpha_{1-2} = \frac{\log P_2 - \log P_1}{\log P_2 - \log T_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

which with not too great values of the differences $T_2 - T_1$ can practically be identified with the derivative function $\alpha = \frac{d \log P}{d \log T}$ at the mean temperature $T_{1-2} = \frac{T_1 + T_2}{2}$. This would be quite exact, if we could consider this part of the curve being a common parabola. For greater values of $T_2 - T_1$ the calculated value of α_{1-2} does no more correspond exactly with the mean temperature T_{1-2} but with a somewhat different temperature involving a systematic error. Each point of the α_{1-2} curve appears to some extent shifted against the true α-curve. But now we have to prove that the α-curve possesses at the critical point a minimum, that means a horizontal tangent. Such a behaviour cannot be influenced noticeably by a small horizontal shifting of the points of the curve; if the new criterion is valid for the $\alpha_{1\text{-}2}$ curve it should also be valid for the true α –curve.

Of course it is difficult to decide whether the available measurements are sufficiently accurate to allow the use of this method, as any accidental fluctuations within the measured value become highly increased when forming differences. There are certainly some limits for the applicability of this method, prescribed by the accuracy of the measurements and by the density of the measured values on the curve. For some measurements this method could not be applied at all, as the calculated values for α have shown quite irregular fluctuations. This was e.g. the case with Porter's measurement on Ethane (7), used in tracing the α-curve for this substance in Figure 1. For so great fluctuations of the measured values there exists no method to determine the second derivative function.

All accurate measurements extending to the critical point which have been available to us have been included in our investigation. Their number is unfortunately not too high, and it was therefore extremely important that the numerous measurements of S. Young and his collaborators (8) have proved to comply with the degree of accuracy desired in this particular problem. This actually enabled us to perform an extensive test.

In Figures 2 to 4 the results of our calculations of $\alpha_{1\text{-}2}$ values following equation (9) are represented for 26 substances measured by S. Young;

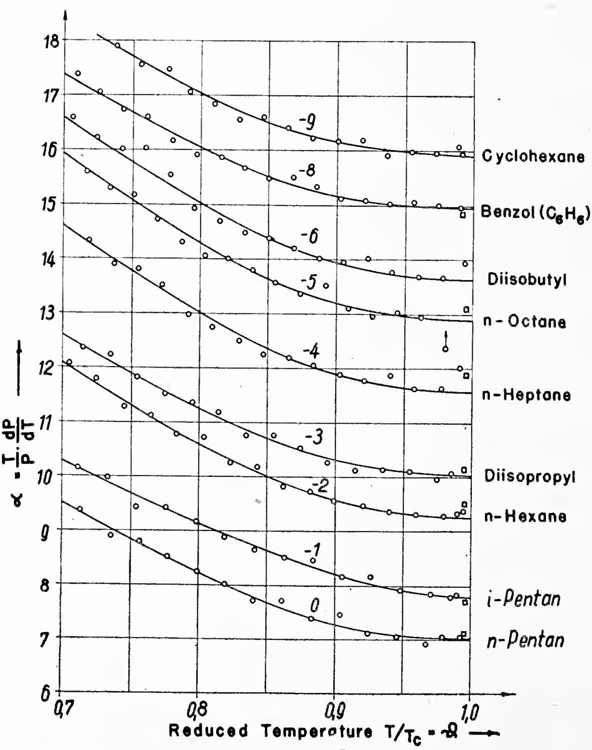


Fig. 2

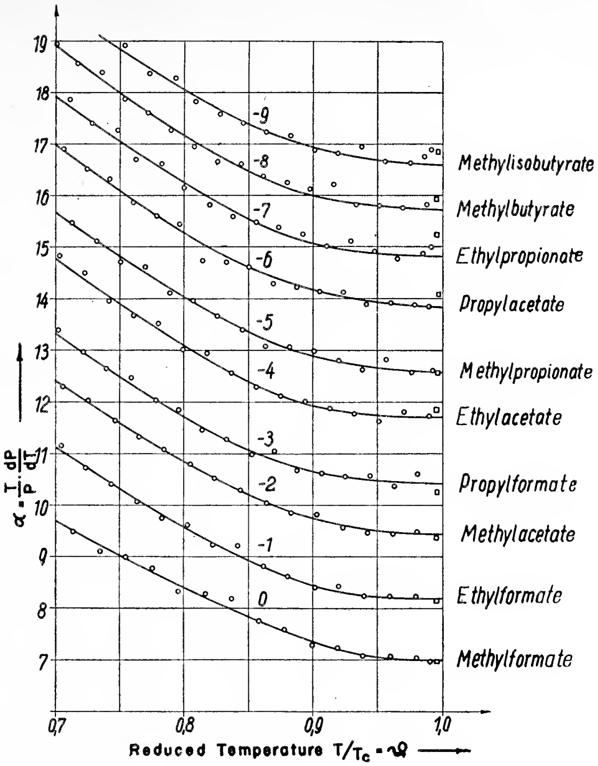


Fig. 3

the values of four other substances contained in the investigation of S. Young have not been considered, as they do not include the critical region. In these figures again reduced temperatures are selected as abscissae, and the curves for different substances have been displaced by a certain amount (recorded for each substance) to avoid coincidence. Young has represented his experimental results by tables in which pressure values are given for round values of temperature from 10 to 10 degrees. Thus the differences $T_2 - T_1$ to be used in equation (9) were regarded as prescribed. For some substances Young gave additional pressure values corresponding to smaller differences of temperature in the vicinity of the critical point, so that we were able to calculate more values of $\alpha_{1\text{-}2}$ in this region. Points marked in the figures 2 to 4 by a square, and situated near the critical temperature $\delta = 1$, have been calculated using the critical data themselves. These points have generally a smaller degree of accuracy due to the small values of $T_2 - T_1$ used in their calculation. Figures 2 to 4 show that with this method smooth curves are obtained, so that the values found seem to be reliable.

The course of all these curves undoubtedly proves the admissibility of the new criterion, requiring a minimum at the point $\delta = 1$, at least within the limits of accuracy of the measurements used. For quite many substances the fluctuations in the vicinity of the critical point are very small, so that the curves can be traced in a very certain manner; this is the case of Isopen-

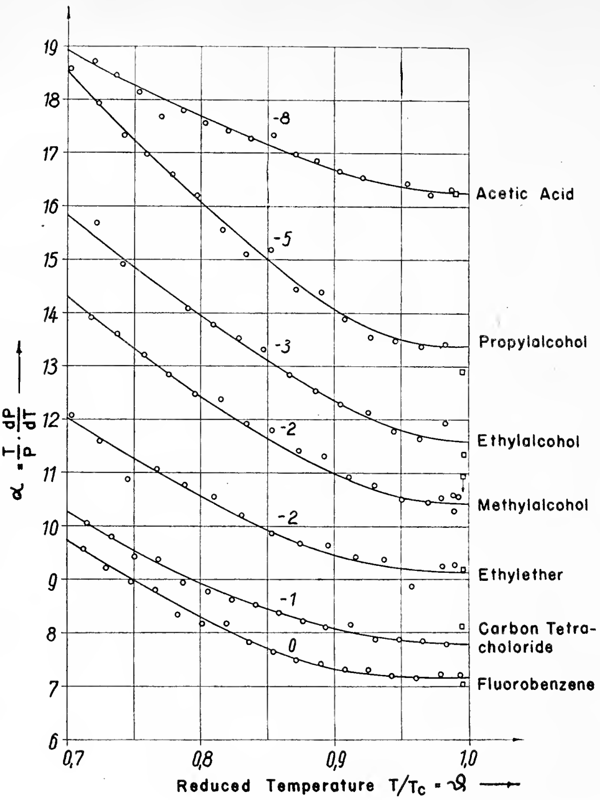
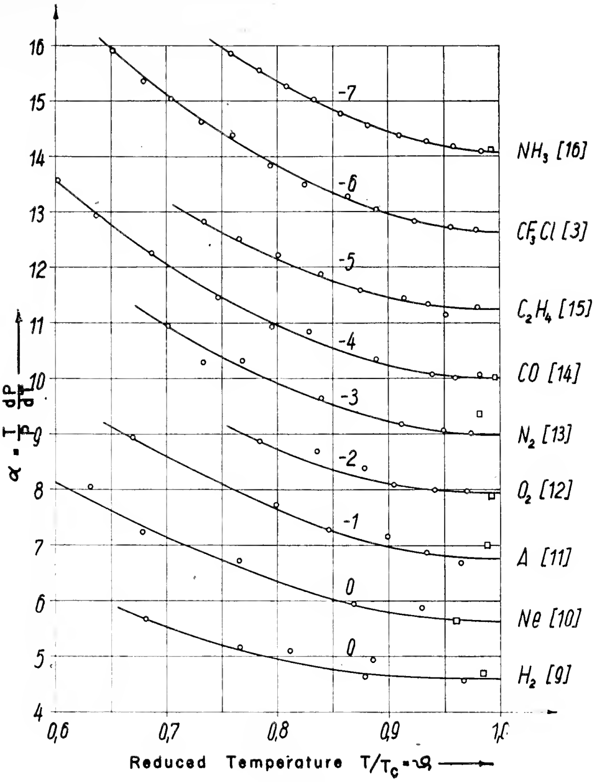


Fig. 4

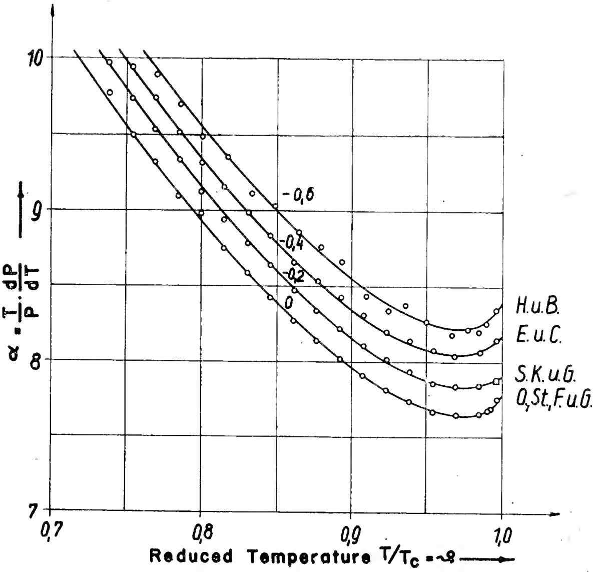
tane and benzene in figure 2, for methyl-formate, ethyl formate and methyl-acetate in figure 3, for fluorobenzene and acetic acid in figure 4. For all these substances there is a clear flat minimum at the critical point; the course of all the other curves is also quite compatible with the assumption of such a minimum. Figure 5 shows the course of the α –curves for 9 other substances, for which reliable values of the vapor pressures are known, mostly originated from the cryogenic laboratory at Leiden (Holland).. For substances with low boiling points the extension of the temperature field is certainly restricted; the precision of the measurements should therefore be higher than for substances with high boiling points, if the same degree of accuracy for the α –curves is aspired to. The results obtained in Figure 5 are therefore quite remarkable; they show that the measurements must have been performed with high precision and they are a further proof for the correctness of the new criterion. We like to call special attention to the results with carbon monoxide for which numerous exact measurements have been made in the vicinity of the critical point (9).

It can be said that all these determinations of α-values based on direct measurements confirm the validity of the new hypothesis within the limits of the exactness of the measurements. And this seems also to be true for associated substances as is shown by the curves for alcohols and acetic acid;



-7
-6
-5
-4
-3
-2
-1
0
0
NH₃ [16]
CF₃Cl [3]
C₂H₄ [15]
CO [14]
N₂ [13]
O₂ [12]
A [11]
Ne [10]
H₂ [9]
α = T/P · dP/dT
Reduced Temperature T/T_c = ϑ

Fig. 5



-0,6
-0,4
-0,2
0
H.u.B.
E.u.C.
S.K.u.G.
O,St,F.u.G.
α = T/P · dP/dT
Reduced Temperature T/T_c = ϑ

Fig. 6

the shape of these curves differs very much from that of normal substances, but they also show a minimum at the critical point.

THE CASE OF WATER

The substance for which the pressure-temperature curve has been measured with the highest possible degree of precision is water. Besides the measurements performed by Holborn and Baumann in 1910 (10) we have three independent more recent measurement of very high precision (1), (2), (4), (11), which permit to test the new hypothesis. The results of these measurements have been represented very exactly by means of different complicated empirical formulas. (See equations (2a) and (2b). The different measurements and formulas show an excellent agreement as to the values of the vapor pressures even in the immediate vicinity of the critical point (deviations less than 0.05%); but in the values of the first derivative and of α the deviations reach already about 1.4% as shown in Table 1. This behaviour confirms our previous statements and makes it very sure that deviations of the second derivative (influencing the validity of our hypothesis) are even much higher.

TABLE 1

Values of $\alpha = \frac{T}{P} \cdot \frac{dP}{dT}$ for water calculated from different empirical pressure-temperature equations (t_c = 374.11°C)

Temperature °C	α–Values of Smith, Keyes and Gerry (4)	α–Values of Osborne, Stimson Fiock and Ginnings (1)	α–Values of Osborne and Meyers (2)
100	13.3229	13.3195½	13.3213
150	11.3479	11.3484	11.3473
200	9.8989	9.8997	9.9006
250	8.8343	8.8368	8.8354
300	8.0738	8.0761	8.0762
350	7.6502	7.6431	7.6440
360	7.6369	7.6341	7.6310
365	7.6769	7.6522	7.6475
370	7.6714	7.6911	7.6920
371	7.6786	7.7013	7.7073
372	7.6861	7.7130	7.7265
373	7.6948	7.7259	7.7529
374	7.7041	7.7401	7.8103

Therefore we have preferred to calculate also in the case of water values of $\alpha_{1\text{-}2}$ following equation (9) and using directly measured values. The results are shown in figure 6, where again the curves are displaced to avoid close coincidence, and where a bigger scale was selected for the ordinates due to the higher precision of the measurements.

The trend of these curves near to the critical point is very surprising. The minimum value of α, which in our hypothesis was always expected to be at the critical temperature $\delta = 1$ is here already reached at the somewhat lower temperature of about $\delta = 0.98$. Between the temperatures of 0.98 and 1.0 there is an unexpectedly steep increase of α. But whilst the pressure values of all investigators nearly coincide up to $\delta = 0.98$, there are quite remarkable deviations for $\delta > 0.98$. The surprising increase of α within this last region is much smaller in the measurement made at MIT (by Smith, Keyes and Gerry [4]) than in those made at the Bureau of Standards (by Osborne and Meyers [2]). These deviations clearly demonstrate the extreme experimental difficulties encountered at the critical region. In spite of the fact that most qualified investigators have treated this region using experimental equipment of highest accuracy, some uncertainties of the values of $\frac{dP}{dT}$ and α still remain.

But there is no doubt that the results of all measurements mentioned above clearly indicate that our new criterion is not strongly valid for water. The question must be raised, whether water, which is known to behave abnormally in every respect, forms in this case an exception, or whether such deviations from the proposed criterion can be expected also with other substances. The course of several curves represented in figures 2 to 5 may indeed give rise to some doubt whether the new criterion is universally valid. This is the case for hexane, heptane and diisobutyl in figure 2, for a few esters in figure 3 and for methyl alcohol in figure 4. But for all these substances the available measurements are surely not accurate enough to allow a final decision on this question. For a great majority of substances there is no experimental evidence contradicting the new criterion; but in the present state of our knowledge we may better define it in claiming that the α*-curve shows a minimum at or very close to the critical point.* This restriction may be regrettable from a theoretical point of view, but it does not degrade the practical signification of the criterion.

IMPORTANCE AND APPLICATION OF THE NEW CRITERION

Independent of the strong or restricted validity of the new criterion, it can be applied to set up reasonable pressure-temperature equations and to determine the coefficient entering such equations. All equations which do not show a minimum of α at or close to the critical point should be rejected, if we like to include the critical region.

From equation (2), which is mostly applied, equation 6 was derived. If T_m is the temperature at which α has a minimum value, then T_m is connected with the coefficients of equation (2) by the condition

$$B = T_m^2 \, (D + 4ET_m + 9FT^2 + \ldots\ldots) \qquad (10)$$

and T_m must be equal or very close to T_c.

It is therefore obvious, that a pressure-temperature relation of the type $\log P = A - \frac{B}{T} + C \log T$, which is in common use, cannot be applied up to the critical point, but should be restricted to lower temperatures.

A four-term equation of a generalized type

$$\log P = A - B/T + C \log T + DT^n \qquad (11)$$

leads to the condition

$$B = n^2 \, DT_m^{n+1} \qquad (10a)$$

or with n = 1

$$B = DT_m^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (10b)$$

Equation (11) with n = 1 is used very extensively, but the numerical values of B and D generally lead to values of $T_m = \sqrt{B/D}$ which differ very much from the critical Temperature T_c. Such values of B and D are inconsistent with the real behaviour of matter in the critical region; pressure values derived from such an equation may coincide with the measurements at the temperatures which have been used to determine the coefficients A to D, but at intermediate temperatures no good agreemnt can be expected.

Of course with more terms in equation (2) a better agreement will be reached, but we have found that with even only four terms a good agreement with measured values can be obtained if we put $n > 1$. Preliminary calculations with a few substances have shown that putting n = 5 or 6 and using equation (10a) with $T_m = T_c$ a very good agreement can be obtained.

The results of such a calculation may be shown for carbon monoxide, for which the vapor pressure curve was determined very exactly by Crommelin, Bijleveld and Brown [9] with many values in the close vicinity of the critical point. These authors have expressed their results by means of the equation

$$\log P = 24.45338 - 544.66/T - 10.217 \log T + 0.02178T \quad . \; . \; . \quad (12)$$

which does not satisfy condition (10b) giving $T_m = 158$, whilst $T_c = 132.47$. So the minimum of α would appear at a reduced temperature $\delta_m = T_m/T_c = 1.192$, which is very improbable.

We have found that the whole set of experimental values can be equally well represented by equation

$$\log P = 8.86774 - 401.314/T - 2.06895 \log T + 0.01524(T/100)^6 \; . \; . \; . \; . \; . \; . \quad (13)$$

satisfying condition (10b).

A comparison of the deviations from experimental values obtained with these two equations is shown in Table 2. It can be seen that equation (13) containing only three constants (n = 6 is regarded as universal value and B is calculated with equation (10a) putting $T_m = T_c$) represents the experimental results in this wide pressure region with the same average accuracy as equation (12).

Equally good results have been obtained with $CClF_3$ using equation (11) with n = 6 and satisfying ondition (10a). Here measurements of L. Riedel have been taken in consideration.

We would like to suggest that equation (11) with n = 6 combined with condition (10a) should be used also for other substances to represent vapor-pressure values up to the critical point. The constant A in equation (11) can be eliminated through the critical values P_c and T_c. Using reduced values for the pressure and for the temperature the vapor-pressure equation becomes

$$\log \Pi = C \log \delta + D' \left(\delta^6 - \frac{36}{\delta} + 35\right)$$

containing only two empirical coefficients, C and $D' = DT_c^6$.

The new criterion can also be used for the determination of the critical pressure, if direct measurements are not available, by extrapolating equation (11) up to the critical temperature.

Attempts to prove the validity of the new criterion (7) by means of theoretical thermodynamic considerations have not yet been successful; one arrives always at undetermined expressions for $(d\alpha/dT)_c$. The criterion could only be based on experimental evidence. The condition is here just the same as with the statement of Bennewitz and Speitberger [12] establishing $(\delta^2P/\delta T^2)_V$ being zero at the critical point. Even the first and second laws of thermodynamics are to be considered as empiric statements, which can only be demonstrated by experience and for which no theoretical proof can be given.

TABLE 2

Comparison of vapor-pressure values for carbon monoxide following equations (12) and (13) with measurement of Crommelin, Bijleveld and Brown (9).

Temperature T°K	Vapor Pressure Measured P Atm	Deviations Δ log P Equation (12)	Equation (13)
132.47	33.902	−0.00000	+0.00003
131.82	32.911	− 21	+ 13
129.23	29.184	− 96	+ 48
129.23	29.160	− 131	+ 21
125.96	25.014	− 58	− 91
123.46	22.152	+ 2	− 153
112.20	12.072	+ 165	− 174
107.62	9.082	+ 23	+ 37
103.48	6.922	+ 160	− 60
94.34	3.473	− 263	− 168
87.61	1.8833	+ 17	− 1
81.45	0.98131	− 39	− 28
77.96	0.64566	+ 1	− 71
73.85	0.37197	− 10	− 1
73.85	0.37198	− 9	− 1
73.86	0.37237	− 44	+ 46
68.17	0.15387	+ 93	+ 154
68.14	0.15292	+ 144	+ 203

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RADIOACTIVE TRACERS IN CHEMICAL RESEARCH

L. O. Morgan
Assistant Professor of Chemistry
The University of Texas

The speakers whom you are to hear in the talks following this one will no doubt present many of the applications of radioactive tracers in the fields of biochemistry, biology and medicine. The general features of such applications are quite similar to those which one would consider in the study of applications to strictly chemical research. This being so, I shall restrict this presentation to applications in the fields of inorganic and physical chemistry.

Radioistopes may be used in chemical and physical studies in a wide variety of ways, not all of them falling within the scope of this discussion. Very roughly, the types of study may be categorized as follows:

1. Radiation chemistry, in which the chemical effects of alpha, beta and gamma rays are studied.

2. The chemistry of "hot" atoms. Some radioisotopes are produced in an excited state which can then emit gamma radiation to produce the ground state of the isotope. The large amount of energy released in the interior of the atom gives rise to some rather profound changes in the molecule of which the "hot" atom is a part.

3. Tracer chemistry. It is assumed that in the first approximation the chemical behavior of a radioisotope of a given element is the same as that of the naturally occurring mixture of isotopes of that element and, hence, that the radioisotope may be used as a stand-in for the natural element. Since the location of the radioisotope may be readily determined, the tracer serves to indicate the location of the gross element.

Strictly speaking, tracer chemistry is a form of analytical chemistry, having some quite unusual and advantageous features:

a) Extremely small amounts of material may be detected. With optimum conditions one could locate and follow 10-20 thousand atoms, although amounts as small as this are not generally used.

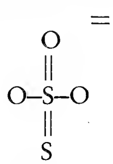
b) Measurements may be made without interrupting the operation of the system. In many cases the radiation from a given radioisotope is sufficiently penetrating that it may be detected externally with respect to the entire system and for some applications such a measurement obviates the necessity for physical sampling. This method finds its most useful applications in the study of the biological systems, but is becoming more and more widely used in laboratory and industrial studies. For example, one may wish to follow the progress of the boundary between two phases in a dynamic system. If one of the phases contains a radioactive material, it is only necessary that one shift the detector along the vessel until a discontinuity in the amount of radiation is detected, thus locating the position of the boundary. Diffusion rates may be measured in the same way, the only limitation being that the appropriate radioisotope have sufficiently penetrating radiation to be detected outside the containing vessel.

c) Because of the small amounts of material that can be readily detected, it is possible to study the behavior of small amounts of material in solutions whose physical nature is almost completely determined by the presence of large amounts of one or more other materials (macrocomponents). For instance, it is of great interest to know how certain molecules distribute themselves between two phases, say liquid-liquid or liquid-solid phases, under a given set of conditions. If amounts of material large enough to be detected by the usual methods are used, their presence may change the nature of the phases. Under these conditions a rate study would demand the consideration of gross changes in the entire system as well as the particular rate being studied. However, the use of a microcomponent, for which the tracer technique applies admirably, would minimize, or remove completely, the difficulties.

d) The tracer technique is able to differentiate between atoms coming from different sources. Anderson, in 1936, (Z. physik. Chem. *B32,* (1936)) was able to show that the structure of thiosulfate ions involved non-equivalent sulfur atoms. Using the reaction:

$$S + SO_3^{=} \text{------} S_2O_3^{=}$$

he added radioactive S^{35} (half-life = 87 days) in the form of elemental sulfur to a sulfite solution to form radioactive thiosulfate. Upon acidifying the thiosulfate solution, he found that the radioactivity was almost all in the sulfur from the decomposition of thiosulfate, and none was with the sulfite. If the sulfur atoms were equivalent in the thiosulfate, the activity would have been equally distributed between the sulfur and the sulfite. Radioactive sulfite and inactive sulfur used in the same reaction leads to the same conclusion. Of the structures, having non-equivalent sulfur atoms, that might be postulated for thiosulfate the most likely is:



which is entirely analogous to the structure of the sulfate ion, replacing one oxygen with a sulfur atom.

e) Radioisotopes may be used in the study of chemical elements which do not exist in nature. Such studies on the chemical behavior of plutonium, using small amounts of plutonium-238, produced in cyclotron bombardments, resulted in the elucidation of the fundamental chemistry of the previously unknown element. The facts thus found were used later in the devising of procedures for the separation of large quantities of the material produced in fission reactors and were found to be accurate, although the scale-up factor amounted to some hundreds of millions.

In studies of this type, it is necessary to study the behavior of the tracer with respect to macrocomponents whose chemistry is known or can be determined by ordinary methods. Then by means of analogy the chemistry of the trace element may be deduced. The general method has been successfully applied to the study of the chemical properties of element 61, technetium (43), francium (87), astatine (85), americium (95) and curium (96). Earlier work of the same general type was done on actinium (89), protactinium (91) and polonium (84). None of these elements, with the exception of protoactinium, exist to any significant amount in nature.

The latter has lately been produced on the gram scale using information gained with tracer studies.

It must be obvious that in this brief time there has not been possible a complete presentation of the potentialities and actualities of the tracer method as applied to chemical research. The adsorption of small quantities of material on active surfaces, kinetic studies of complex systems, analyses of materials whose quantitative determination is otherwise difficult or impossible; all these, and more, have been successfully attacked by the methods of tracer chemistry.

BIOCHEMICAL APPLICATION OF TRACERS *

Wiktor W. Nowinski
Associate Professor of Neurochemistry and Research Associate
Tissue Culture Laboratory
University of Texas Medical Branch
Galveston, Texas

The progress of our present-day science is essentially a progress in methods and technique. As soon, therefore, as the first possibility of the production of isotopes on a large scale occurred, the biochemist immediately became interested in the application of tracers, seeing in it an important tool for research and a new approach to his problems. In the great majority of cases, the biochemist has considerable difficulty in isolating the intermediate products of reactions; therefore, the ability to investigate the fate of labeled substrates and inorganic components in the metabolism of the body and thus following reactions step by step, seems to open new and extremely important horizons.

The idea of using isotopes in biochemistry occurred for the first time to Hevesy, exactly twenty-five years ago (1923). He diluted the nitrate of Pb^{212} with nitrate of common lead and studied the distribution of this element after immersing roots of Leguminosae in the solution for 24 hours, and estimating afterwards the radioactivity of the ash. He found that not only does the root take up lead in great quantities, but also that this element is in the plant in a dissociated form and, therefore, is not combined with an organic compound.

The discovery of deuterium in 1932 (Urey) and the production of heavy water in relatively large amounts, which followed two years later, enabled the biochemist to use this compound extensively, particularly in the study of the fate and metabolism of water in the organism. The problem of heavy water, and particularly that of its toxicity, aroused a considerable interest, an interest which found its way even into a detective story by Van Dine ("The Casino Murder Case"), where a man is supposed to be poisoned by heavy water placed in a decanter, instead of ordinary water. We know, however, that heavy water was found non-toxic after all and that according to Hevesy and Hofer (1934), the ingestion of two liters of a strong solution does not produce harmful effects: to the same conclusion, by the way, comes Van Dine's detective also!

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Along with the development of the technique of isotope preparation, the use of the tracers became more and more extensive and we already face a very large literature on this subject, as may be judged from the book by Kamen (1947) and the recently published symposium on the use of isotopes in biology and medicine (1948), the excellent book by Hevesy (1948) and others. As in all such situations, we can observe also a certain abuse of the method. There is work carried out with it, which actually could be done with simpler methods at much lower cost.

Because of the very large literature on the use of tracers in biochemistry, it is not possible to give even a very general survey in a short space. We pick out, therefore, some interesting examples on the basis of which the great importance of isotopes in biochemical research could be demonstrated.

The tracers are widely used in almost all branches of biochemistry, namely:

1. The fate of organic compounds in the body and their synthesis (this includes the substrates for enzymatic activity as well).

2. Enzymatic activity and its mechanism.

3. Distribution and metabolism of inorganic compounds, including the problems of electrolytes.

4. Permeability.

As far as the first point, the fate of organic compounds and their synthesis in the organism, is concerned, the work on the formation of amino acids and the synthesis of glutathione, may serve as an example.

Foster, Schoenheimer and Rittenberg (1939) and Rittenberg, Shoenheimer and Keston (1939) showed that rats fed labeled ammonia, use it for the synthesis of amino acids; they, furthermore, found the isotope in the glutathione (a tripeptide, Glutamyl-Cysteinyl-Glycine), which was isolated from the liver and intestines of rabbits. Some 69 per cent of the tracer was deposited in the glutamic acid and there was four times less of the isotope in the isolated cystein than in the glycine. The amount of isotope, however, isolated from the rest of the liver proteins, corresponded to 1/10th of that in the glutathione. From these results the authors concluded that the synthesis of glutathione is quicker than that of the cell proteins. They found, furthermore, that the liver protein fraction contains twice the amount of the tracer than does the non-protein fraction; this showed the direct utilization of ammonia for the synthesis of proteins.

In 1941, Waelsh and Rittenberg labeled glycine (with N^{15}) and observed that already by 2½ hours after administration, this amino acid was taken up much quicker by glutathione than by the liver proteins. In 1942, the same authors produced evidence that labeled glutamic acid is incorporated into the glutathione of the intestines and the liver of the rat and that it is found in much greater quantities in glutathione than in the rest of the proteins of the same organs.

One step further in the direction of synthesis of glutathione in the organism was made by Bloch and Anker (1947) who incubated *in vitro* rat liver slices with labeled glycine. They found that the synthesis of glutathione occurred at a rate of 0.1 to 0.2 mg per 1 g of tissue and 1 hour of incubation, which corresponds to the results of Waelsch and Rittenberg *in vivo*. Bloch and Anker demonstrated also that minute amounts of the tracers were present in a fraction precipitable by trichloracetic acid, concluding from this fact that the liver is capable of synthesizing proteins even *in vitro*. Some evidence that the synthesis actually takes places had already been indicated by the work of Anifsen, Beloff, Hastings and Solomon (1947) who labeled the carboxyl groups of aspartic and glutamic acids with C^{14}, and also from the work of Melchior and Traver (1947) who worked with labeled methionine.

We can see from the example mentioned that not only the fact of a direct synthesis *in vivo* and *in vitro* of glutathione from cysteine, glycine and glutamic acid was demonstrated, but also that there is a competitive synthesis between glutathione and the liver proteins. The speed of the synthesis of the glutathione was also demonstrated, a finding which hardly could be investigated with the usual methods, because of the small amounts of compound which are formed.

For the enzymologist, the use of tracers presents a particular interest. Let's take as an example the problem of CO_2 assimilation in certain bacteria, and the fixation of the carbon dioxide in reaction products. Baker and Kamen (1945) found that Clostridium thermoaceticum assimilates labeled carbon (C^{14}) and forms acetate during fermentation. In this acetate both carbons are labeled; the reaction is as follows:

$$C_6H_{12}O_6 + 2H_2O \longrightarrow 2CH_3COOH + 2CO_2 + 8H$$
$$2C^*O_2 + 8H \longrightarrow C^*H_3.C^*OOH + 2H_2O$$

We see here that the isotope was fixed in the acetic acid both in the methyl group as well as in the carboxyl group.

Krampitz, Wood and Workman (1943) isolated an enzyme from Micrococcus lysideikticus, the oxalacetate p-carboxylase. This enzyme converts oxalacetic acid into pyruvic acid. When oxalacetate was incubated with labeled CO_2 (C^{13}) until half of the acetate was converted into pyruvate, it was found that the oxalic acid which remained contained the tracer in the carboxylic group situated near the methylene group:

$$CH_3 \,.\, CH \,.\, COOH + C^*O_2 \longrightarrow HOOC^* \,.\, CH_2 \,.\, CO \,.\, COOH$$

These results confirm the extraordinary specificity of enzymatic activity, because they show that the enzyme exclusively attacks one definite group, located in a definite position. We knew about this specificity from experiments with classical methods, but the use of tracers enables us to point out the group directly. There is, however, another interesting aspect of the work of Krampitz, Wood and Workman: as were present in the digest only substrate, the enzyme preparation and CO_2 (plus added magnesium ions) and the tracer was found only in the oxalacetate, the reversibility of the reaction was directly demonstrated, i.e., the formation of oxalacetic acid from pyruvic acid.

In a similar way, Weinman, Morehouse and Winsler (1947) showed that succinic acid labeled with deuterium exchanges hydrogen ions in positions ζ and ζ_1 from the solution in which it is dissolved, thus confirming the succinic acid contains two hydrogens in the mentioned position which can be activated and, therefore, that the succinic acid dehydrogenase, by splitting off these hydrogens, converts succinic acid into fumaric acid:

$$\begin{array}{l} CH_2.COOH \\ | \\ CH_2.COOH \end{array} \qquad \begin{array}{l} CH.COOH \\ \| \\ CH.COOH \end{array} + 2H$$

The metabolism and importance of inorganic constituents of the body were also extensively studied. The problem of iodine metabolism and iodine fixation in the thyroid was investigated in detail (see for instance Chaikoff and Taurog, 1948). Greenberg and his associates using isotopes, confirmed directly the fact, that in the case of ricketts, there are disturbances in the phosphorus assimilation, but not—as it was once supposed—in that of calcium. Also, the fate of iron was studied to a great extent. So, for instance, it was shown (Granick and Hahn, 1944) that great quantities of labeled iron in its ferric state are taken up by blood and in a few hours deposited in the liver. Hahn, Granick, Bale and Michaelis (1943) made the following experiment: after bleeding a dog, they injected ferric ammonium sulfate in which the iron was labeled, feeding the animal liver at the same time in order to stimulate the hematopoisis. They observed a very rapid regeneration of erythrocytes with the iron isotope as a component of the heme of the hemoglobin. Of this labeled blood 110 ml. were injected into a normal dog which received on the next day an injection of acetylphenylhydrazine in order to increase the destruction of red blood corpuscles. In a subsequent analysis of the ferritin, an iron-protein compound, in the liver and the spleen of this animal they demonstrated a direct passage of heme into the ferritin, obtained in crystalline form.

The study of permeability with tracers permits a direct determination of the passage of a compound through the cellular membrane (Brooks and Brooks, 1941). In the course of such studies it appeared, however, that the permeability of the isotopes may be different from that of the stable element. In spite of this handicap, by combining different methods with that of tracers, the passage of a compound may be fairly well evaluated. Unless, therefore, it is definitely proven that the rate of permeability of the isotope is equal to that of the stable element, no decisive conclusions can be drawn from the tracer experiments alone.

I have made an attempt, in the short time at my disposal, to demonstrate the diversity of problems which can be studied with tracer elements. However, there is one problem, which seems to me to be the fundamental problem of all biochemistry and towards which all our research is actually directed: how the organic and inorganic compounds in the cell are converted into living matter? Are there any hopes that the use of tracers will bring us nearer to its solution?

I am quite aware of the fact that to play a role of prophet is both unrewarding and dangerous. Our approach to the formation of living matter may be, after all, not so much a question of methods and techniques but of our mental attitude: maybe that we are sometimes a little too vitalistically, another time too mechanistically inclined. It may be that we cannot yet understand the fact that organization is not an exclusive attribute of living matter (a heritage, I think, from Aristotle), but that it can be traced on different levels throughout the organic and inorganic world (Needham 1942). It seems to me that potentially, at any rate, the use of isotopes may throw a certain light upon this fundamental problem. To some scientists it may seem that it is not a scientific problem at all, that it belongs rather to the realm of metaphysics. In my opinion, however, attempts to approach it have always to be in our minds and I fully agree with Roger J. Williams who in his book "The Human Frontier," says: "In the broadest sense, any kind of investigation which has for its purpose the discovery of truth is scientific."

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APPLICATION OF TRACERS IN BIOLOGY AND GENETICS

Robert P. Wagner
Department of Zoology
The University of Texas

The exceedingly wide application of stable and radioactive isotopes in the field of biology precludes presenting a summary of the methods and results obtained in the short time I have at my disposal. Such varied aspects of physiology as the transfer of materials across the cell surface, transport of materials in plants, photosynthesis, physiological activity of chemical compounds in intermediate metabolism, etc., have been investigated with the use of isotopes as tracers, and in many cases fruitful results have been obtained. It is my purpose here to go into some detail concerning one specific biological problem involving the use of tracers, and to use this as an example of the methodology used, the line of reasoning employed and the results obtained.

The specific problem I refer to is the determination of the biological role of the nucleic acids in the cell. The nucleic acids, in combination with proteins to form the complex nucleoproteins, are universally present in living matter. All organisms from the virus on up have this group of compounds represented as important chemical constituents.

The virus seems to be little more than a certain type of nucleoprotein capable of reproducing itself. The chromosomes in the nuclei of the cells of higher forms of organisms are mostly nucleoprotein, and the cytoplasm of these cells is nearly always liberally endowed with it. In addition, breakdown products of the nucleic acids are in most cases present, particularly in the cytoplasm, where they function as important compounds in metabolism. Chemical analysis of the nucleic acid portion of the nucleoprotein complexes have shown that there are two general types, desoxyribonucleic acid confined to the nucleus, and ribonucleic acid found both in the nucleus and cytoplasm but usually more highly concentrated in the cytoplasm. Investigation of the chemistry of the chromosomes has revealed that desoxyribonucleic acid is present in a relatively high concentration in those regions which genetic analysis has indicated to be the site of the genes, or at least the sites which appear to have gene activity. Studies on the ribonucleic acids in the nucleus and cytoplasm have indicated that they may be involved as a source of material for synthesis of desoxyribonucleic acid and more important as sites of protein synthesis.

These general observations concerning the nucleic acids make it obvious that they play a very important role in cell biology. They seem in all cases to be associated with the reproductive capacity of the cell, i.e., the ability of the organism to reduplicate itself. In addition the specific type, desoxyribonucleic acid, appears in combination with its protein to be the chemical constituent which determines, in part, the final characteristics of the organism, due to its intimate association with the regions of the chromosomes where the genes are most likely located. Supporting evidence for this probable role comes from the previously mentioned observation that the nucleic acids may be involved in the synthesis of proteins. The relationship of the role of the nucleic acids in protein synthesis to their presumed role as the determiners of the characters of organisms is not at first sight evident. But when it is remembered that the physiological functions of the organism which determine its characteristics are actually, to a large extent, if not completely, made up of complexes of biochemical reactions which are in turn under the control of specific enzymes or catalysts, then the relationship becomes clear. For enzymes are proteins, each enzyme being a specific type of protein which controls a specific type of biochemical reaction. Thus specific proteins must control final characters, and the specicity of the protein must be given to it when it is synthesized.

The problem, as can be seen by its statement above, is an important and complex one. Let us now consider what further information has been gotten concerning it by the use of the radioactive isotope P^{32}. This isotope is a valuable one to use in this connection because of the fact that all nucleic acids have phosphoric acid as an important part of their molecules, the phosporic acid being important not only from the structural, but from the functional point of view as well. The usual method of getting the P^{32} into the cell is by feeding it to the organism in the form of inorganic phosphate, such as disodium hydrogen phosphate. If the organism used is a complex one such as a rat, the labeled phosphate will be found in the tissue cells within a few hours after injestion in maximum concentration provided no further labeled material is injested. Once the level of the labeled phosphate has reached a temporary stability(which will be changed mainly by excretion) in the tissue fluids and in the cells themselves, one may proceed to determine what specifically is happening to the atoms of P^{32} within the cell. Since we are interested here in the phosphate tied up to the nucleic acid in the cell, we proceed as follows: Several hours or days after injestion of the labeled phosphate the rat is killed, certain of the organs removed and the desoxyribonucleic acid, let us say, isolated from the rest of the cell contents by chemical means. The specific activity (counts/unit time/mg.) of the P in the compound is determined and also the specific activity of the P in the inorganic phosphate of the cell which is assumed to form the reservoir of available phosphate. The ratio

$$\frac{\text{specific activity of nucleic acid P}}{\text{specific activity of inorganic P}} \times 100$$

is calculated. This term is called the percent turnover of phosphate in nucleic acid, or more simply the phosphate turn-over rate of nucleic acid. The general assumption is now made that the high rate of turnover of a compound during a physiological process implies that this compound may be important in the process, particularly if the high rate of turnover is unique to that compound, and is not found at all or to any great extent in other compounds with similar atoms. Thus the turnover rate in nucleic acid phosphate is taken to be a measure of the activity of the nucleic acid in performing its biological role. The validity of this assumption is by no means yet proven, but it may be used tentatively as an indicator, pending further information on the activity of nucleic acids.

Experiments performed employing this technique on rats have yielded very interesting results. They show that the turnover of phosphate in the desoxyribonucleic acid in adult rats is measurable, but much lower than the phosphate turnover in the ribonucleic acid. For example, the phosphate turnover in adult rat liver ribonucleic acid is about 33 times greater than the desoxyribonucleic acid turnover. All other organs examined showed approximately the same relationship between the ribo and desoxy acids. With regard to the differences between adult organs in the desoxyribonucleic acid turnover it was found that in general those organs which carry on active secretion or cell proliferation were highest in rate of phosphate turnover. If, on the other hand, phosphate turnover is determined in the nucleic acids of foetal or regenerating rat tissues, the turnover was found to be much higher in both types of nucleic acids than is the case in adult tissues. In addition the difference between the turnover rates in desoxyribo- and ribonucleic acid is not as marked, and in some cases the turnover of the former may exceed the latter, a condition just opposite to that found in adult tissues.

A tentative conclusion may be made here from these results to the effect that the turnover of nucleic acid phosphate, particularly that of the desoxyribonicleic acid is stimulated by cell division. Support for this conclusion may be drawn from other experiments involving P^{32}. It is known that irradiation with X-rays inhibits mitosis (cell division) in tissues. If tissues from rats irradiated with X-rays are examined with respect to turnover it is found that these tissues have a much lower turnover of desoxyribonucleic acid phosphate than the control tissues. Another experiment of interest in this connection is one concerning the phosphate turnover of the hen erythrocyte. The erythrocytes of birds are nucleated cells formed in the red bone marrow which do not undergo mitosis in the blood stream. P^{32} may be introduced into these cells while they are being produced in the bone marrow and the labeled cells then followed into the blood stream. Here it is found that all phosphate compounds in the cells lose the labeled phosphate by exchange with unlabeled phosphate in the blood plasma except the desoxyribonucleic acid which retains the P^{32} for the duration of the life of the cell. These data make our conclusion seem convincing, and we may modify it now to state that the turnover of desoxyribonucleic acid is definitely correlated with mitosis or cell reproduction. The role of ribonucleic acid is, however, not made much clearer by these experiments, for while it is true that the rate of phosphate turnover goes up in this compound during mitotic activity, the fact still remains that ribonucleic acid is very active in resting cells, whereas desoxyribonucleic acid is quite inactive.

Yeast cells have been used in experiments with P^{32} phosphate in an attempt to definitely link the nucleic acids with the synthesis of protein. The procedure in this case was to determine the phosphate turnover of all phasphate compounds in the cell in the presence and in the absence of a source of nitrogen. Phosphate turnover was much higher when the cells were incubated with a source of nitrogen insufficient to provide for cell division for nearly all phosphate compounds including the nucleic acids, than when the cells were incubated in a nitrogen free medium. These results are inconclusive as far as the nucleic acids and protein synthesis are concerned, and we can only conclude that phosphate turnover goes up in general when protein synthesis is actively proceeding in the cell.

The use of tracers in the problem of the role of the nucleic acids in the cell has thrown light on some aspects, and raised further questions concerning certain other aspects. Certainly the supposition that the nucleic acids are important in cell reproduction and the final determination of characters receives some direct support, and there is good evidence that a further application of this technique will bring more support.

One of the difficulties implicit in applying the tracer technique to a biological problem such as the one discussed above has already been pointed out. It was seen that the phosphate turnover may be active in all phosphate compounds under certain conditions in the case of yeast. When this is so, no conclusion can be drawn concerning the unique activity of a specific phosphate compound. Another significant difficulty arises in the chemical isolation of compounds, particularly compounds such as the nucleic acids. In yeast it is, for example, difficult to separate the two acids quantitatively, and since there is considerably more ribonucleic acid than desoxyribonucleic acid in the yeast cell a slight contamination of the latter with the former will give results which may lead to erroneous conclusions concerning the relative activities of these two compounds.

It can be seen from the examples and discussion presented that the application of tracers to various biological problems, such as problems arising in genetics, is capable of producing valuable results.

THE USE OF TRACERS IN THE FIELD OF MEDICINE

Allen F. Reid
Southwestern Medical College
Dallas, Texas

I have been very fortunate in having a large portion of my subject given for me by the previous speakers, because the field of medicine embraces the application of most of the chemical and biological sciences, not merely as additional tools, but as part and parcel of medical work itself. You can immediately see how the uses reported by Dr. Wagner and Dr. Nowinski are directly applicable, and you can see the extensions of the same type of work which could be and are, to a certain extent, used in the field of medicine. So I should like to spend a little time in pointing out some of the differences in techniques and precautions over and above those used in biochemical and biological applications of tracers when they are used in medical work. Some of these precautions, it is true, must be taken in the other fields to a certain degree, but their use in medicine is imperative to protect the safety of the individual.

PRECAUTIONS

In the first place, many medical operations become more involved by the necessity of using sterile techniques in their application. Another concern, when using radioactive tracers, is to use as small doses as is compatible with the proper functioning of the tracer experiment. Some of you may well wonder why, as long as the tracer dose is kept low enough so that the radiation given is less than the accepted permissible level. The answer to that is simple: it has not yet been established that the body can completely recover, in time, from the effects of small amounts of radiation. That means that it may be subjected to some cumulative efferts of radiation from radioactive tracer materials. In fact, some investigators have shown what they believe to be pretty good evidence that even permissible level radiation dosage will cause pathological change.

Another precaution which must be taken in the use of radioactive tracers in medicine is the high criterion of radioactive purity. In tracing biochemical reactions outside the human body, some concern is necessary about other radioactive materials which might be present. But in the case of the use of these materials for medical application, even one millionth of the tracer dose radioactivity of the wrong element might concentrate itself in some organ and become the site of irritation and possibly subsequent neoplastic growth.

Now I should like to divide the use of tracers in medicine into two main classifications—distribution tracers and function tracers. I should like to give you a few examples—of which there are very many—in each category.

DISTRIBUTION TRACERS

If a radioactive tracer is introduced into the blood stream its appearance can be detected wherever the blood flows. That is one of the most simple and yet fairly important means of determining blood distribution and blood circulation kinetics. It has been used in some centers, already, as a diagnostic aid for certain conditions; and of course, as these tracer techniques are a comparatively recent addition, they can be expected to develop much further in this as in other related problems. A slight modification of that is in determining the fluid volume of the individual. This can be done by using a sampling technique, in which either a stable or a radioactive material may be introduced, a sample taken and analyzed. Heavy water has been used very successfully, and non-concentrating ions such as radioactive sodium ions can also be used because of their great ionic activity. Permeability of membranes to any molecule or ion can be determined merely by introducing such a molecule with an isotopic label on one side of the membrane and analyzing the material on the other side. One of the most evident problems to be solved by the isotopic tracer technique is the determination of blood volume. Until isotopic techniques were available, dyes of various kinds were introduced into the blood stream and their dilution measured after the dye had assumedly been completely and uniformly distributed. That suffered from the disadvantage that in its passage through the various organs and through blood vessels contiguous to the tissues any non-toxic dye is absorbed or chemically changed. However, if red blood cells are stably labeled such a situation will not exist, and it is possible to determine the dilution which such cells have experienced. It has been found that by incubating red cells in a physiological saline solution containing radioactive phosphorus for a short length of time, enough radiophosphorus will have exchanged with the phosphorus in the cell so as to make a satisfactory red cell tracer in which loss of the radiophosphorus is not too rapid when the cells are in the blood stream.

FUNCTION TRACERS

Function tracers, of course, include all of the biochemical tracer applications, but only a comparatively few of them have become useful as standard practice in the body. One of the best known function tracers is radioactive iodine, which collects preferentially in the thyroid tissues. The rate of uptake of iodine by these tissues has been used as a diagnostic measure, and in a few rare cases has been used to determine the distribution of thyroid cancer metastases. Another similar type of function tracer is the labeled dye which concentrates in lesions. A particular example of that is the use of dibrom trypan blue labeled with radioactive bromine, which has been used by many laboratories throughout the country. A slightly different type of function tracer is radioactive phosphorus in its use to determine the rate of metabolism of various cells. Since the metabolic rate in some forms of cancer towards utilization of phosphorus is greater, it is possible to differentiate between these malignant cells and normally functioning cells by their uptake of radioactive phosphorus. Finally, I want to use as an example the determination of the life of red blood cells using an isotopic tracer. This seems a simple problem. First you label the red cell, and then from time to time you determine what percentage of the labeled red cells still exist. Radioactive iron immediately leaps to the mind as being a good tag for the cell. But there we run into this involvement: upon destruction of the red cell the released iron is re-utilized in synthesis of a new cell. That, however, is not true of radioactive phosphorus. But even though radioactive phosphorus can be used to tag the red cell, its life compared to the life of the red cell is so short that a tremendous activity would have to be used. Furthermore, we do not have enough evidence to show that the phosphorus would remain in the cell throughout its entire life. Upon going over one possibility after another, we find that there is no available radioactive isotope which can be used to label red cells satisfactorily for this determination. It becomes necessary to use the stable isotope of nitrogen, allow red cell synthesis with nitrogen-labeled glycine, and then determine the surviving N^{15}- labeled red cells from time to time.

One of the medical uses of isotopic tracers which is still in its infancy is a combination of the distribution and the function tracer technique in radioautography. An example of that is in the use of radioactive iodine, which "stains" thyroid tissue in the portions of the iodine-metabolizing tissue and not in the other portions. When such tissue is placed near to a photographic emulsion one then has a radiomicroautograph of the tissue, which has proved to be of use and extreme interest to pathologists and other scientists concerned with the differential functioning of the tissue. You can see how such a method can be extended to possibly as great a region as there is at present in conventional staining differentiation.

There is a further possibility of utilizing isotopes which preferentially absorb neutrons, using a neutron beam as x-rays are used conventionally to give a diagnostic picture. This may be impractical, but if practical it might be extended to therapy, also.

It can be seen that there are many channels through which isotopic tracers may be used in medical science. I have not even mentioned the many research projects which probably will be the most valuable application of these tracers. I should like to leave you with the thought of a not so far-fetched but a fantastic appealing method. That is the taking of an isotopic pill and the subsequent analysis of certain of the body fluids for the isotopic content of certain compounds as a routine diagnostic procedure. Some of the foremost investigators in these fields say that there is a distinct possibility that such a time is coming. As a matter of fact, the determination of the life of a red cell using labeled glycine is very close to one example of that.

LIQUID HELIUM THE FOURTH STATE OF MATTER

C. F. Squire
Assistant Professor of Physics
The Rice Institute
Houston, Texas

Texas produces for the world of science and industry a unique product in gaseous helium. The U. S. Bureau of Mines operates a plant at Amarillo for the separation of the gas. In submitting this article to the Texas Academy, we aim to tell of the amazing properties of the gas when cooled to a liquid at 457 degrees below zero Fahrenheit (minus 269 degrees Centigrade). Some of the research has been done by us here in Texas, but by far the greater portion of the story is pieced together from research laboratories spread throughout the world. Such laboratories as Leiden (Holland), Paris (France), Cambridge (England), and Moscow (Russia) are but a few of the important ones who have drawn the helium gas from the Texas gas fields. And the outgrowth of some twenty years of intensive research has brought one international agreement (among scientists); the liquid helium is so unlike all other liquids known to man that it must be set in a separate category and called the fourth state of matter. So we have now: (1) gas, (2) liquid, (3) solid, (4) liquid helium.

The techniques of obtaining such low temperatures as to permit the liquefaction of helium gas is itself a story of consuming interest to engineers and scientists. But we will set this aside in order to cover at once the properties of liquid helium. The phase diagram giving a plot of pressure against temperature (Figure 1) reveals some interesting experimental facts. The most startling is that the helium remains a liquid on down in temperature to the absolute 0° K. Only by applying a pressure of some 25 to 30 atmospheres can one obtain the solid phase; thus one has to force the liquid into the solid state.

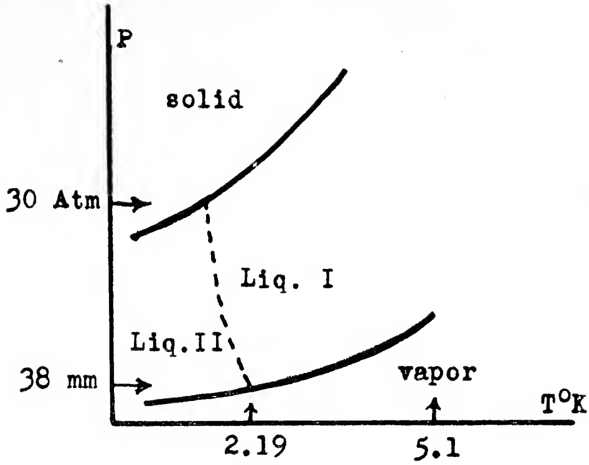

Fig. 1

Again examining the phase diagram (Figure1) we see that there are two kinds of liquid called I and II. It is liquid helium II which is the fourth state of matter. A plot of the specific heat against the temperature (Figure 2) shows a large hump at the transition temperature separating the two liquid phases. Such a specific heat hump is found in many substances where so-called "second order" transitions take place. One can compute the entropy change involved in the transition from liquid II to

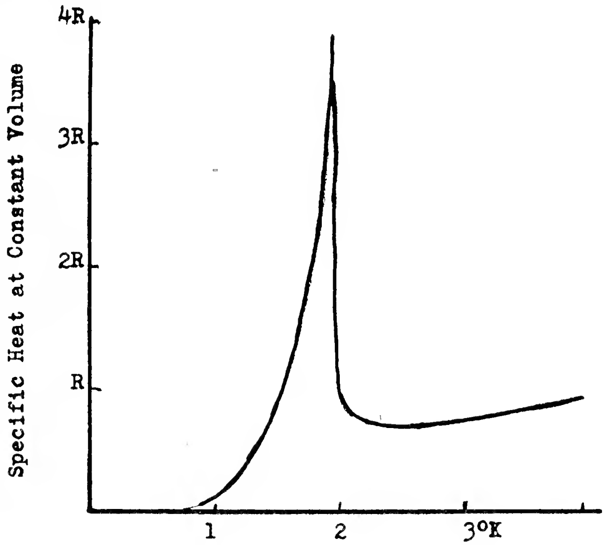

Fig. 2

liquid I by simply integrating the specific heat curve. The rapid drop of entropy below the transition point tells us that the helium is attempting some sort of ordering process but that this is not an ordering ino a solid crystal phase. At pressures corresponding to its own vapor pressure the helium definitely stays a liquid. So the ordering process on going from liquid I to liquid II has been attributed to an ordering in momentum space rather than in distance space. This peculiar condensation of the helium atoms in momentum space was actually predicted by Professor Albert Einstein [1] years before its discovery experimentally. Einstein's ideas were taken up again by Prof. F. London,[2] and the essential point which one must grasp is that the helium atoms obey quantum mechanisms even on a macroscopic scale.

There are a few other physical properties of liquid helium II which deserve our attention and which serve to emphasize the difference between this liquid and all other liquids known. In Figure 3 we plot the coefficient

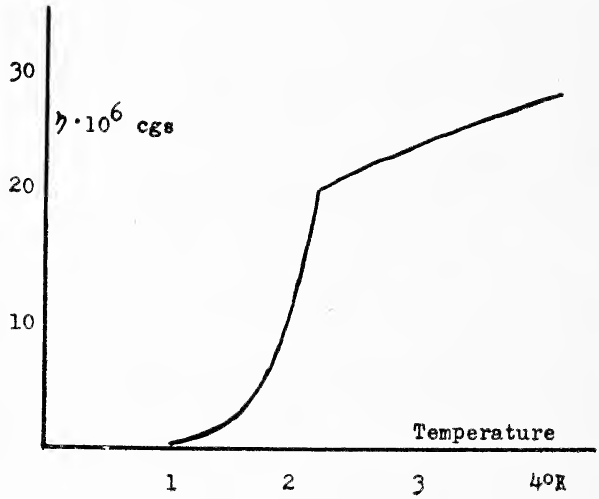

Fig. 3

of viscosity against the absolute temperature. At temperatures below about 1.5° K the liquid has almost zero viscosity! In addition to this, experiments show that liquid helium II is by far the best heat conducting substance we know; it is about 200 times that of copper at ordinary temperatures and about 14 times that of very pure copper at liquid hydrogen temperatures. Out of a theory to explain these effects of the quantum liquid there came a prediction by L. Tisza [3] of the existence of temperature waves (sometimes called second sound). Heat energy can be propagated in liquid helium II by a wave mechanism having a velocity of propagation of about 20 meters per second. The prediction was quantitatively verified by the experiments of Peshkov in Russia and later by Lane [4] at Yale University.

Returning to the plot of viscosity in Figure 3, we notice that even in liquid helium I the dependence on temperature is most unusual. All other liquids show an increase of viscosity with lowering temperature. We must conclude that even liquid helium I has unusual properties and that it behaves more like a gas than it does a genuine liquid. As a matter of fact, the density of liquid helium I turns out to be less than one might expect from the size of the atoms. This small density and the small latent heat

[1] **A. Einstein.** S.-B. preuss. Akad. Berlin, 261, 1924; 3, 1925.
[2] **F. London.** Phys. Society Cambridge, p. 1, 1947; Phys. Rev. 54: 947 (1938)
[3] **L. Tisza.** J. Phys. Radium **1**: 164, 350 (1940); C. R. Acad. Sci. **207**: 1035, 1186 (1938)
[4] **Lane, et al.** Phys. Rev. **70**: 431 (1946)

of vaporization have contributed further experimental evidence of the quantum mechanical nature of macroscopic quantities of helium.

Recently the isotope of helium with mass 3 has been obtained in considerable quantity as a by-product from the nuclear fission piles set up by the Atomic Energy Commission. The isotope of mass 3 shows gross physical properties which are quite different from the ordinary mass 4 helium atoms. These experiments bring us up to date with the present state of affairs and their interpretation promises to throw much light on our basic understanding of matter. Thus a basic raw material from Texas has played an important and interesting role in the role of science. At the Rice Institute in Houston, there exists a laboratory for the cooling of helium into the liquid state, and it is with considerable pride that we offer our modest contributions to the field of low temperature research.

INDIUM-CHROMIUM FILM BEHAVIOR AS REVEALED BY THE ELECTRON MICROSCOPE

Leland L. Antes
Bureau of Engineering Research
The University of Texas

INTRODUCTION

The properties of electro-plated chromium are quite generally known. There are certain characteristics of chromium plate which make it very satisfactory as a decorative material, but as a protector of iron or steel surfaces it is very poor. This failure to protect may be attributed to the formation of microscopic cracks in brittle electro-plated chromium.

These cracks in chromium plate are due to tremendous tensions built up parallel to the surface as the thickness increases. This can be readily shown by dissolving the base copper away from a thin electro-deposited layer of chromium. Under this condition the thin chromium curls immediately into tight cylinders having a diameter of perhaps .01 inch. Assuming that the thickness of the plate is in the neighborhood of .0005 inch it will be evident that the stress in the uncurled chromium plate must have been very high.

In the investigation of electro-plated chromium by electron diffraction it has been found by Donald Marshall and the author (1948) that the first layer of chromium deposited on a copper surface gives no indication of crystalline structure. As the thickness of this electro-deposited layer is increased, there is evidence of increasing crystal size and a very strong tendency for crystal orientation with the 111 crystal surface parallel to the base. A theory for the development of this tension as the thickness increases would seem necessarily to involve the increasing size or preferred orientation of the crystallites, and any means of inhibiting the growth and preferred orientation of the chromium crystallites should reduce the formation of surface stresses.

EXPERIMENTAL WORK

Investigations of metallic thin layer phenomena have been undertaken with the help of the electron microscope and a high vacuum apparatus for producing thin specimens of a type quite suitable for electron microscope and electron diffraction work. The similarities between such vacuum deposited layers and those electrolytically deposited are marked.

Indium metal has an unusual crystalline structure. It is essentially a face centered cube with the cube elongated eight per cent in one direction. Films of indium which have been deposited by condensation in vacuum show the effect of relatively high surface tension as evidenced by the electron micrograph of Figure 1. Molecular rays released by heating indium in contact with a tungsten filament travel radially until they strike a cool surface, such as a microgrope specimen slide. The surface tension of indium is high compared to that of the parlodion surface on which the molecules impinge and the indium molecules then migrate to build up the patchwork structure shown. Examination of this thin indium film by electron diffraction indicates that a very high preferential orientation exists.

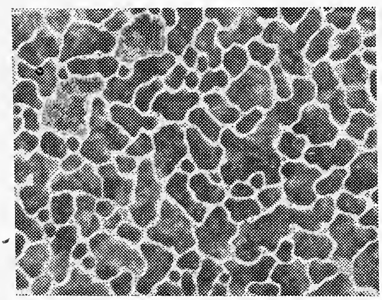

Fig. 1

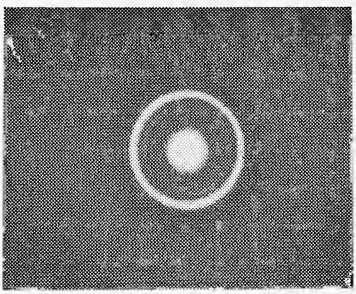

Fig. 2

Films of chromium made by this same vacuum technique show fine crystalline structure with minute cracks developing somewhat as in the electro-deposited films. The electron diffraction patterns made from these thin chromium films show no preferred orientation but do indicate again, by the unsharpness of the rings, a fine crystalline structure. As the thickness of the layer increases, the sharpness of the rings increases, indicating larger crystallites.

When chromium and indium are deposited simultaneously by the vacuum technique it is found that the crystal structure of the chromium can be partially destroyed, or at least the size of the crystals can be reduced to a minimum. This is perhaps due to the odd crystalline structure of indium. There is also evidence for the formation of a chrome-indium alloy. This is illustrated in the diffraction pattern of Figure 2 in the form of additional rings on either side of the strong ring which represent neither chromium nor indium.

When a thin layer of indium is deposited first and this is followed by chromium or chromium with indium, electron micrographs of the multilayer thus built up will show mainly the characteristic indium design. The diffraction patterns of such multi-layers show a variety of effects, but indicate essentially that the chromium crystalline structure can be de-emphasized by the inclusion of the indium. The typical indium structure alone is indicated by electron diffraction unless the percentage of indium is less than approximately 50 per cent. An electron micrograph of such a layer, high in indium content, shows the indium in large, irregular patches. An edge view of this layer indicates that the indium builds up on the parlodion surface in smoothly rounded droplets. If the percentage of indium is reduced below about 5 per cent, the chromium diffraction pattern is not seriously affected, but indium in the ratio of about 10 per cent, and under proper conditions of deposition, prevents the formation of any but the smallest chromium crystallites. The electron microscope structure of these chrome-indium films is always very smooth. Cracks do not develop, nor is there any tendency for a relatively thick metallic layer to destroy the parlodion film by curling and breaking as is always the case with pure chromium deposits.

In conclusion it may be said that vacumm deposited chrome-indium films in which the indium content is approximately ten per cent possess properties having considerable advantage, in that the internal stresses parallel to the surfaces of the films seem to be greatly reduced. This quality is apparently due to a reduction in crystal growth as thickness increases, perhaps stemming from the unusual crystalline characterics of indium. Preservation of these qualities in electroplated layers would be of advantage, and investigations along these lines are being carried out.

The author wishes to express genuine appreciation for the assistance of Dr. Norman Hackerman of the Department of Chemistry. Dr. Hackerman also furnished the rare metal indium.

LITERATUTE CITED

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THE EFFECT OF THE BACTERIA *VIBRIO DESULFURICANS* ON THE PERMEABILITY OF LIMESTONE CORES

Oliver D. O'Bryan
Sun Oil Company

Ta-Wei David Ling
Department of Petroleum ngineering
University of Texas
Austin

PURPOSE OF INVESTIGATION

Luling crude is produced from the Edwards limestone. There are numerous kinds of oilfield bacteria in water produced from the same formation. Bastin (1930) has proved negatively that the bacteria in oilfield waters come from the oil-producing formations. Plummer (1946) shows that "four types of organisms are present in oilfield waters and appear to play a principal part in producing harmful precipitates; that is, iron bacteria, sulphur-oxidizing bacteria, sulphate-reducing bacteria, and blue-green algae."

The water phase of the reservoir fluids is usually in contact with the reservoir rock and is said to wet the rock surface (Leverett, 1941). The above mentioned bacteria exist in the water phase of the reservoir fluids; therefore there is the possibility of the precipitation of solids due to bacterial action and the deposition of these solids on the walls of the pore space.

Such deposition reduces the size of the pore space. Any solid precipitation from the salt water of the oil-producing formation will not change the porosity of the reservoir rock appreciably but may decrease the permeability of reservoir rock notably (Ling, 1948).

This theoretical reasoning should be confirmed by laboratory experiments. The Edwards limestone, then, was chosen as the porous medium. The bacteria *Vibrio desulfuricians* were used for there was sulphate in the Luling oilfield water subject to reduction by these bacteria. Synthetic water was prepared and used according to the average analysis of the Luling water.

REACTION OF THE BACTERIA VIBRIO DESULFURICANS WITH SULPHATE IN WATER ASSOCIATED WITH PRODUCING FORMATIONS

The bacteria *Vibrio desulfuricans* are known as sulphate reducing bacteria. The effect of these bacteria is to reduce the valence of sulphur from plus six, in sulphate, to minus two, in hydrogen sulphide. Hydrogen sulphide thus formed will react with metallic ions in the water solution of salts to form sulphide precipitates. Any excess of hydrogen sulphide causes the crude in the reservoir to be designated as sour.

For instance, the reduction process of magnesium sulphate by the bacteria in the presence of hydrocarbons may be expressed by the following equations:

$$MgSO_4 + 2\ HOH \rightleftharpoons Mg(OH)_2 + H_2SO_4$$

$$H_2SO_4 \rightleftharpoons 2\ H^+ + SO_4^{--}$$

$$SO_4^{--} \xrightarrow[\text{presence of Hydrocarbons}]{\text{Reduction by Bacteria in the}} H_2S + 4\ H_2O$$

$$Mg(OH)_2 \rightleftharpoons Mg^{++} + 2\ OH^-$$

$$Mg^{++} + H_2S \longrightarrow MgS \downarrow + 2\ H^+$$

$$2\ H^+ + 2\ OH^- \longrightarrow 2\ HOH \text{ or } 2\ H_2O$$

The rate of reduction of the sulphate by bacteria in water solutions is described by Plummer and Walling (1946):

> Analyses show that at 125° F. bacteria alone reduce sulphates in East Texas salt water by only 3 per cent in 30 days, forming principally hydrogen sulphide and sodium or calcium hydroxide. The hydrogen sulphide reacts with soluble iron compounds to produce iron sulphide where oxygen and air are present. Where iron or other metals and iron sulphide are already in water containing bacteria 100 per cent reduction of the sulphates is complete in 30 days or less; where magnesium is present, reduction is complete in 15 days.

The synthetic Luling water contains magnesium and calcium, the combined reaction of which is similar to that of magnesium alone. The reduction of sulphate in the synthetic Luling water should be completed theoretically in about 15 days.

PROCEDURE

Eight cores were cut from a piece of the Edwards limestone. The permeability of each individual core was measured. Four cores were treated differently for the injection of the bacteria. The other four, treated under individual conditions similar to the cores injected, served as controls in order to obtain some means of correction of errors from sources other than the effect of the bacteria. After a period of four months following the injection process, the cores were cleaned and the permeability of each core was then remeasured.

The results were tabulated and compared.

Details of the procedures are described as follows:

PREPARATION OF THE CORE

Eight cores were cut from a piece of the Edwards limestone obtained at its outcrop; and turned to uniform diameters of seven centimeters. They were then sawed to a length of seven centimeters, faced, and bored to 1.1 cm. The final core was a 7 cm by 7 cm cylinder with a bore of 1.1 cm.

Intermittent sterilization was employed to sterilize the cores. The cores were covered with the synthetic Luling water * and heated to 200° F. for a period of 18 hours, and allowed to stay in the synthetic water for 72 hours at room temperature. This process was repeated three times. This precaution was not made for the purpose of obtaining sterilized cores but for killing off any anaerobes that might be present. Air contaminants were not considered detrimental.

After sterilization the cores were mounted axially between sheet-iron discs with De Khotinsky hard cement; the top disc was bored to receive an 11-mm glass tubing 25 cm in length, which was fixed thereto by sealing wax (see Figure 1).

The cores were dried by passing dry air through them for twelve hours.

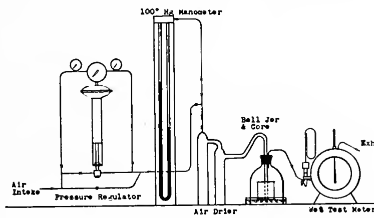

Figure 1. Permeability Measurement Apparatus Arranged for Radial Flow.

DETERMINATION OF CORE PERMEABILITY MEASUREMENT

The permeability of each core was measured as specified in the American Petroleum Institute Code No. 27 (1942). The apparatus is shown in Figure 1. The pressure of the air admitted to the system was properly regulated and was indicated by the 100-inch mercury manometer, before the air enters the air drier. Dry air of a known pressure was forced to flow through the core radially from inside-out under the measured pressure gradient. Air which had passed the core was trapped by the bell and the mercury seal, directed to flow through the wet test meter, and vented to the atmosphere.

Before the test, the wet test meter was proved against a "precision" one-tenth-cubic-foot bottle, certified by the U. S. Bureau of Standards. The accuracy of the meter was within one half of one per cent.

The time required for one-tenth cubic foot of air (measured at room conditions) to flow through the core, as well as the manometer reading, the barometric reading, the room temperature, and the dimensions of the core, were observed and recorded.

* Analysis of the synthetic Luling water is given in the Appendix.

CALCULATION

Calculations involved the application of Darcy's formula which was modified for the radial flow of gases:

$$k = \frac{Z\ Q_b\ P_b\ \ln(r_e/r_w)}{(\pi)\ t\ (P_e^2 - P_w^2)}$$

Where, k = permeability of the porous medium in darcys,
Z = viscosity of the flowing gas in centipoises,
Q_b = rate of flow of gas at the base pressure expressed in milliliters per second,
P_b = base pressure in atmospheres,
π = 3.1416,
t = height of the cylindrical core in cm,
r = radius in cm,
P = pressure in atmospheres,

Subscript e denotes up-stream conditions,
Subscript w denotes down-stream conditions,
ln denotes natural logarithms, and
The rate of flow from outside toward the bore is considered to be of positive sign.

With the amount of flow determined the rate of flow can be calculated. The barometric reading after correction may be converted to atmospheres and used as the down-stream pressure. The sum of the down-stream pressure and the manometer reading, expressed in atmospheres, is equal to the up-stream pressure. At a known temperature, the viscosity of the flowing gas may be obtained from tables.

A part of the data of the permeability determination is shown in Table 3. The permeability k was obtained graphically as shown in Figure 2.

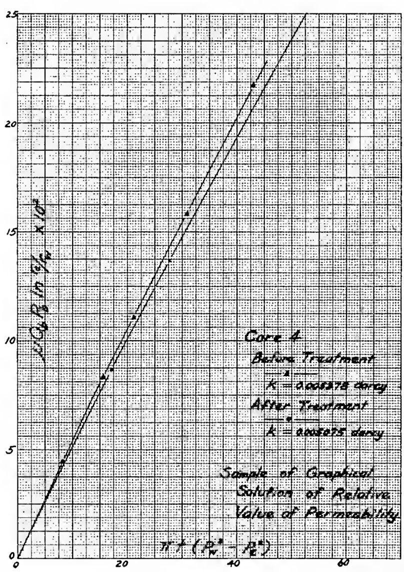

Fig. 2

PREPARATION AND INJECTION OF THE BACTERIA VIBRIO DESULFURICANS

As noted previously bacteria *Vibrio desulfuricans* were cultured in the synthetic Luling water. The necessary hydrocarbons for feeding the bacteria were furnished by sodium lactate * (one gram per gallon). Anaerobic conditions were developed and maintained in gallon jugs stoppered with three-hole rubber stoppers. A long glass tube filled with oil was inserted through one of the holes to provide a seal and at the same time allow for expansion and contraction. The remaining two holes of the stopper were plugged with paraffin and were used in extracting the culture under anaerobic conditions (Figure 5).

On August 18, 1947, the bacteria had grown 60 days in the new culture. At that time a representative sample was prepared and the density of growth measured in a phototurbidometer. The population was found to be 4,500,000 bacteria per milliliter. The pH, also measured at that time, was found to be 6.64 (a decrease of 0.56 from the initial pH of 7.20 of the synthetic Luling water). These conditions were considered to be favorable and suitable for this type of injection.

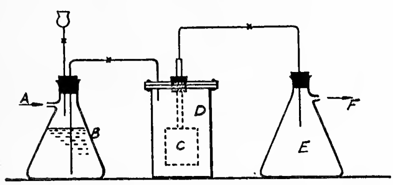

Figure 3. Core to be Brine Wetted.

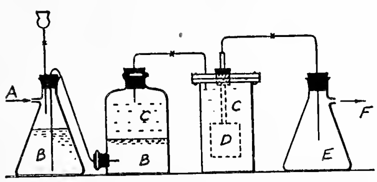

Figure 4. Core to be Oil Saturated.

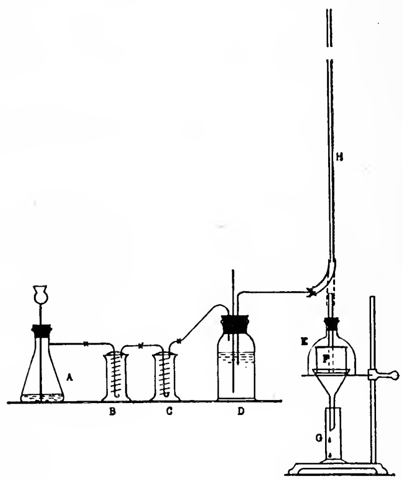

Figure 5. Transfer of Bacteria Culture under Anaerobic Conditions.

SATURATION OF THE CORES

Cores should be saturated with liquids before the injection of the culture, in order to maintain anaerobic conditions and to simulate reservoir fluid saturations. The dried and weighed core (Figure 3, C) was sealed in the pressure vessel (Figure 3, D) and evaculated through the bore to an absolute pressure of 2 mm Hg. The vacuum sump (Figure 3, E) was evacuated by the vacuum pump (Figure 3, F) and was used to trap any liquid passing through the core. While maintaining this vacuum, synthetic Luling water was added to the pressure vessel gradually by opening the valve between (B) and (D) slowly and by applying air pressure (A) finally up to

* Sodium lactate ($NaC_3H_5C_3$) is available as a mixture with water containing 70-80% sodium lactate, which is a colorless or almost colorless, thick, odorless liquid. The solution is neutral and miscible with water or alcohol or both.

Table 1. Water and Oil Saturation Data.

Core	Water Saturation: Weight, Dry gms	Water Saturation: Weight, Wet gms	Water Saturation: Wt. of Water Injected gms	Water Saturation: Pressures mm Hg abs. P_w	Water Saturation: Pressures mm Hg abs. P_e	Oil Saturation: Weight after Oil Injection gms	Oil Saturation: Pressures mm Hg abs P_e	Oil Saturation: Pressures mm Hg abs P_w	Oil Saturation: Volume of Water displaced, ml
A	600.3	657.76	57.73	41	1547	654.19	34	1558	34.3
B	575.87	650.35	74.48	34	1561	646.65	51	1553	43.4
C	618.48	668.45	50.03	46	1553	The core is saturated with 20% sodium lactate water solution.			
D	603.67	657.50	53.83	46	1556	Saturated with the brine.			
1	511.29	559.60	58.31	49	1558	557.04	41	1548	35.6
2	535.50	601.60	66.10	46	1565	597.60	38	1551	43.5
3	544.65	602.12	57.47	41	1561	The core is saturated with 20% sodium lactate water solution.			
4	540.17	601.05	60.88	41	1560	Saturated with the brine.			

Specific gravity of brine: 1.0209
Specific gravity of oil : 0.8446

one atmosphere gauge. After saturation, which took at least one-half hour, the core was removed and weighed.

The core was then returned to the pressure vessel and, with the apparatus modified as shown in Figure 4, covered with crude oil before starting evacuation. Evacuation was necessary to saturate the core with oil. In oil-saturating the core, compressed air was used to displace the brine (Figure 4, B), which, in turn, forced the crude oil (Figure 4, C) into the pressure vessel, in order to fill up the remaining pore space of the core (Figure 4, D) with the crude oil or to displace a portion of the brine in the large pores. By so doing, the hazard of the explosive mixture of the lighter portion of crude and the air was eliminated. The core was then removed and weighed.

Cores were treated differently. Four cores (A, B, 1, and 2 in Table 1) were "water-wet and oil-saturated" in the described manner. Two (C and 3) were saturated with a 20% water solution of sodium lactate. Two (D and 4) were saturated by brine. Cores 1, 2, 3, and 4 were subjected to 100 ml of the *Vibrio desulfuricans* culture under the hydrostatic head of from 4 to 11 inches of water for the slow migration of the bacteria across the core. The other set of the cores (A, B, C, and D) were used as controls and were subjected to a similar migration of the synthetic Luling brine. If the hydrostatic head proved to be too great, a clamp or stopper permitted regulation of the rate of flow.

INJECTION OF THE CULTURE

As anaerobic conditions were necessary at all times, the introduction of the *Vibrio desulfuricans* culture to the cores was not a simple procedure. The injection was accomplished with the aid of a nitrogen generator in the following manner:

A 60-inch length of 11-mm glass tubing (Figure 5, H) was connected to the core assembly (F) by means of a short length of Tygon tubing, as shown in Figure 5 by dotted lines. In Figure 5, the core assembly was resting on a funnel, which collected the liquids displaced from the core and permitted them to drop into a graduated cylinder (G). Nitrogen was generated in the nitrogen generator (A), and then the nitrogen was washed by a solution in the basic washer (B) and then by water in the neutral washer (C). The nitrogen was then used to force the culture out of the jug (D).

A 25-ml pipette was filled with crude oil and used to punch one of the paraffin plugs in the jug containing the culture. The top of the pipette was connected to the lower end of the Tygen tubing. After the generator was in operation for sufficient time to purge the lines, the last washer was connected to the top of the culture by punching out the other paraffin plug. The nitrogen forced the culture out of the jug through the pipette, with the oil seal ahead of the culture, and into the 11-mm glass tubing (H). The oil floated on the culture and thus sealed the latter from the oxygen in the air. When the tube was filled to a desired height, the flow of nitrogen into the jug was stopped. The height was calculated by dividing the cross-sectional area of the opening of 11-mm tubing into the volume of the culture required which included an extra amount for undetermined losses.

The Tygon tubing was then clamped ¾ of an inch from its lower end, disconnected from the jug, and placed on the top of the short glass

Core	Run	Baro. Press. Reading mm Hg.	Corr. Baro. mm Hg.*	Pe Atmos.	ΔP cm Hg.	Diam. cm. 2 re	Bore 2 rw	Temp. °C.	Vol. of Flow, cc.	Time of flow, sec.	Qb cc./sec.	μ c.p.	Pb Atm.	ln (re/rw)	Y**	t cm	Pw−Pe = ΔP atmos.	Pw+Pe atmos.	X***	k darcys
A	1	751.0	747.2	0.9832	32.5	6.90	1.11	22.3	2832	1747.8	1.620	0.018185	0.9832	1.828	0.05275	7.22	0.428	2.394	23.2	
	2		747.2	0.9832	50.7			22.3		987.0	2.87	0.018185	0.9832		0.0935		0.664	2.634	39.8	
	3		747.3	0.9833	72.7			22.0		642.0	4.41	0.018175	0.9832		0.1440		0.957	2.924	63.5	0.002274
B	1	749.3	745.5	0.9810	25.7	7.02	1.11	24.0	2832	823.6	3.44	0.01827	0.9810	1.844	0.1135	7.23	0.3382	2.300	17.66	
	2				41.1			24.0		484.4	5.85	0.01827	0.9810		0.1930		0.541	2.503	30.7	
	3				68.0			24.0		269.8	10.50	0.01827	0.9810		0.3467		0.895	2.857	58.0	0.00643
C	1	749.6	745.6	0.9811	25.2	6.96	1.11	23.8	2832	2347.0	1.206	0.018265	0.9811	1.836	0.03966	7.21	0.3321	2.294	17.24	
	2		745.9	0.9814	46.1			23.0		1204.3	2.35	0.018225	0.9814		0.0772		0.6065	2.569	35.35	
	3		745.9	0.9814	68.1			23.0		743.2	3.76	0.018225	0.9814		0.1234		0.8965	2.859	58.1	0.00230
D	1	749.6	745.9	0.9814	29.7	6.91	1.11	23.0	2832	2494	1.135	0.018225	0.9814	1.830	0.0372	7.28	0.391	2.354	21.02	
	2			0.9814	47:9			23.0		1433.5	1.974	0.018225	0.9814		0.0646		0.6306	2.593	37.40	
	3			0.9814	74.0			23.0		864.2	3.28	0.018225	0.9814		0.1073		0.974	2.937	65.45	0.001766
1	1	754.2	750.4	0.9874	17.3	6.87	1.11	22.0	2832	1477	1.918	0.018175	0.9874	1.822	0.0626	6.40	0.2276	2.202	9.63	
	2			0.9874	37.0			22.0		638.8	4.44	0.018175	0.9874		0.1449		0.4870	2.462	24.14	
	3			0.9874	56.7			22.0		392.2	7.223	0.018175	0.9874		0.236		0.7464	2.721	40.85	0.00650
2	1	754.2	750.4	0.9874	22.1	6.83	1.11	22.0	2832	1067.5	2.655	0.018175	0.9874	1.816	0.0864	6.97	0.2910	2.266	14.44	
	2			0.9874	35.8			22.0		643.2	4.40	0.018175	0.9874		0.1431		0.4712	2.446	25.24	
	3			0.9874	57.9			22.0		367.0	7.714	0.018175	0.9874		0.251		0.7676	2.742	46.05	0.00598
3	1	750.6	746.8	0.9826	27.4	6.87	1.11	22.2	2832	826.4	3.424	0.01818	0.9826	1.822	0.1102	6.93	0.3608	2.326	18.29	
	2			0.9826	40.0			22.2		522.0	5.425	0.01818	0.9826		0.1747		0.5264	2.492	28.54	
	3			0.9826	64.5			22.2		296.4	9.55	0.01818	0.9826		0.3102		0.8495	2.815	52.0	0.00603
4	1	751.0	747.2	0.9832	26.0	6.81	1.11	22.3	2832	1053.2	2.684	0.018185	0.9832	1.813	0.0869	6.89	0.3422	2.309	17.11	
	2			0.9832	39.0			22.3		670.9	4.22	0.018185	0.9832		0.1366		0.5140	2.480	27.58	
	3			0.9832	66.5			22.3		357.8	7.915	0.018185	0.9832		0.2562		0.8751	2.842	53.9	0.005075

Table 3. Data on Permeability Determination after Injection of the Bacteria.

* Corrected for temperature, altitude, and latitude.

**$Y = \mu Q_b P_b \ln(r_e/r_w)$

***$X = \pi t (P_e^2 - P_w^2)$

tube connecting the bore of the core and the outside of the core. The short glass tube was filled with oil before making any connection. A small portion of the culture was permitted to flow downwards by "cracking" the clamp slightly. The air trapped in the Tygon tubing below the clamp was thereby expelled. The tubing was then pulled down over the short glass tubing to form a good seal.

Brine was introduced into the control cores in a very simple way, since it was unnecessary to maintain anerobic conditions during the process. The glass tubing (H) was filled with the synthetic Luling water and was then connected to the core assembly.

The culture was introduced to the cores on August 23, 1947; the rate of migration of the culture as well as that of the brine was regulated by manipulating the clamp on the short length of Tygon tubing. The culture remained in the cores for four months.

EXTRACTION OF THE CORE AFTER INJECTION

In the middle of December, 1947, the cores were cleaned by a suitable method. The crude oil in the pore space was removed by the process of solution of the crude in clean oil solvent, diffusion of the solvent in the pore space, and displacement of the used solvent in the pore space by clean solvent. The process was repeated. After drying in a vacuum oven, any salt deposited in the pore space was removed by a similiar method except that fresh boiled distilled water was used to replace the oil solvent. The core was dried before its permeability was measured again.

MEASUREMENT OF THE PERMEABILITY OF THE RECLEANED CORES

The permeability of each of the recleaned cores was measured in a radial-flow cell with the air as the flowing fluid. The flow was from inside out radially under pressure gradient ranges similar to those used for the determination of permeability before the introduction of the bacteria. The data were calculated and plotted for the determination of the permeability as before.

Table 4. Summary of the Results of Permeability Determinations.

Core	Perm., darcys Before Treat.	Perm., darcys After Treat.	Change in Perm., %	Net Change in Perm., %
A	0.00207	0.00274	+ 32.4	
B	0.00605	0.00643	+ 6.28	
C	0.00230	0.00230	0.00	
D	0.001583	0.001766	+ 11.56	
1	0.00566	0.00650	+ 14.82	− 17.6
2	0.00571	0.00598	+ 4.72	− 1.54
3	0.006384	0.00603	− 5.55	− 5.55
4	0.005378	0.005075	− 5.64	− 17.2

Where, A, B, C, and D are control cores; while 1, 2, 3, and 4 are four cores to which the bacteria were introduced.
A, B, 1, and 2 were "water wetted and oil saturated"; C and 3 were saturated with 20% water solution of sodium lactate; D and 4 were saturated with brine.

INTERPRETATION OF RESULTS

The results of the experiment are summarized in Table 4. The net change in permeability of the core is calculated with the aid of the following equation:

$$C_n = C_i - C_c$$

Where, C_n = the net change in permeability in percentage,
C_i = the change in permeability of the core injected with the bacteria culture in percentage, and
C_c = the change in permeability of the control core in percentage.

The permeability of the cores varied in the order of several millidarcys. It would be reasonable to assume that the cores were of fairly uniform porosity, but the difference in permeability was thought to be due to the variation in size of the capillary channels connecting the pores. With the above assumption the data may be interpreted as follows:

1. The effect of the bacteria was to reduce the permeability of the limestone core, since the net change in permeability of the cores injected was negative.

2. As long as the walls of the pore space were wetted by water the effect of the bacteria remained similar. Core 1 was completely water wetted, and Core 4 was saturated with water. They had similar change in permeability. On the other hand, Core 2 had a much higher oil saturation than Core 1, and its reduction in permeability was much less than that of Core 1. An explanation of this phenomena might be: the sour crude oil hindered the action of the bacteria in deposition of sulphides on the walls of capillary openings as a result of poor water-wall contact or of the detrimental action of the crude to the health of the bacteria, or of both.

3. Sodium lactate water solution did not have any effect on the change in permeability of the limestone cores as shown by Core C.

4. Lack of sulphate in Core 3 might be the reason for its smaller change in permeability. The culture was prepared in the synthetic Luling water, but the reduction of sulphate in the culture was complete before injection, for it took sixty days to prepare the culture. The limited sulphate for reaction with bacteria was supplied bv the fresh synthetic water only, injected at the sametime as the culture. Therefore Core 3 had less reduction in permeability than Cores 1 and 4.

5. Most of the cores had an increase in permeability which may have resulted from the dissolving action of the water containing carbon dioxide absorbed from the air.

RECOMMENDATIONS FOR FUTURE WORK

The bacteria *Vibrio desulfuricans* decreases the permeability of limestone cores in the presence of an ample supply of the food and sulphates, and under favorable conditions. Future work should be done with attention paid to the following factors in order to obtain additional substantiating data concerning the effect of the bacteria on changes in the permeability of oil-producing formations:

1. Anaerobic conditions should be preserved after the introduction of the culture in order to prevent the air from killing the bacteria, and also to prevent the carbon dioxide from the air to dissolve in the water as noted previously.

2. Fairly uniform sandstone cores bonded by siliceous cementing material should be used for the experiment to eliminate the possible acidification of the calcereous material by the dissolved carbon dioxide and water solution.

3. Sulphate-reducing bacteria other than *Vibrio desulfuricans* should be used to prove that the reduction in permeability is due primarily to the action of sulphate-reducing bacteria and the subsequent precipitation of sulphides.

4. A culture of a combination of several species of bacteria may give some idea of the combined effect.

5. Extensive work on the environment of the sulphate-reducing bacteria will give new valuable data for future research.

6. This investigation has been carried out under atmospheric pressure and temperature. Higher pressures and temperatures such as those found in the reservoirs if used as experimental variables should facilitate the prediction of the behavior of the bacteria in actual petroleum reservoirs.

7. Research on methods for regulating reservoir conditions to counteract the action of the bacteria is of paramount practical importance.

8. Slippage occurs along the wall of the flow channels when gases are used as flow media. Therefore, in the determination of core permeability a suitable liquid should be substituted for the dry air used in this experiment. The alternative would be to apply the formula derived by Klinkenberg.[5] According to his equation, the permeability of the porous medium to gas is proportional to the reciprocal of the pressure of the gas. More runs should be performed for air as the flowing fluid in order to obtain enough data for the graphical solution of his formula for the specific permeability of porous medium.

9. The region adjacent to the bore of the core might be one of turbulent flow, even though viscous flow conditions are still maintained in the region farther away from the bore. In the determination of the permeability of a sandstone core, the formula derived by Elenbaas and Katz[3] should be used in the calculation of the permeability after the determination of additional sand data, such as porosity, sphericity, and average particle diameter.

ACKNOWLEDGEMENTS

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APPENDIX

*Average Analysis of Luling Water**, [4]

Radical	*Parts per Million*
Calcium	918
Magnesium	375
Sodium	3,347
Bicarbonate	1,048
Sulphate	824
Chloride	6,582

Total Solids: 13,194
Specific Gravity: 1.008
pH of the synthetic Luling water: 7.20**

* Average of 21 water samples; 5 collected in 1923, 8 in 1924, and 8 in 1929.
** Laboratory measurement.

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ULTRASONIC VELOCITY IN BERYLLIUM AT VERY LOW TEMPERATURES

W. C. Overton, Jr.
The Rice Institute
Houston, Texas

EXPERIMENTAL METHOD

A recent development, "the ultrasonic pulse technique," provides an accurate experimental means for measuring the velocity of sound in solid, liquid and gaseous media. This technique involves the use of a pulsed radio frequency oscillator, a broad-band radio receiver, a radar type oscilloscope for accurately measuring time differences between pulses and a quartz electromechanical transducer.

The function of these components is as follows (Fig. 1). The oscilloscope, a DuMont Type AR-256-D Radar Range Scope, has a crystal-controlled timing circuit which starts the time base and simultaneously sends a trigger pulse to the oscillator circuit. The radio frequency pulse formed by this oscillator is amplified and then passes through an impedance match-

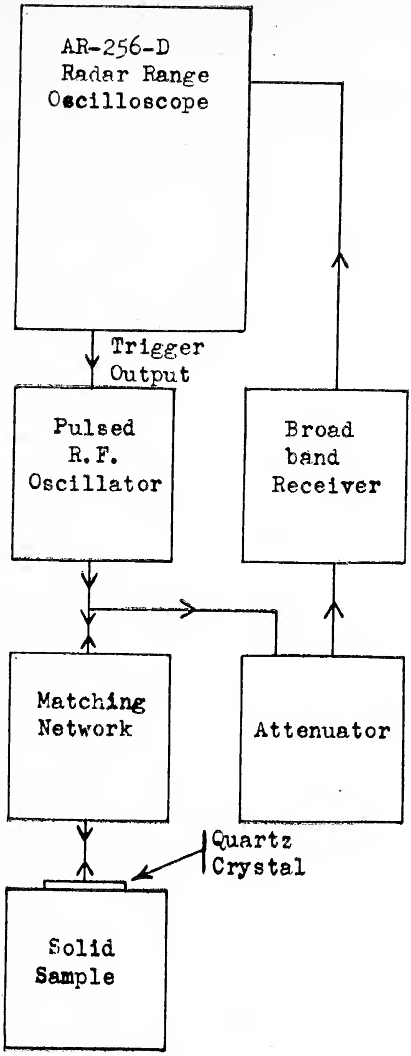

Fig. 1

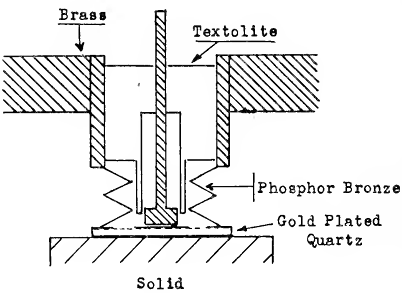

Fig. 2

ing network to the quartz electromechanical transducer. The r.f. pulse is transformed by the transducer into a sound pulse which travels into the medium.

If the medium is a solid the end faces are made parallel, so that when the sound wave strikes the face opposite the transducer it is reflected. After a round-trip through the solid the sound pulse strikes the transducer causing it to vibrate mechanically. This transducer then changes the sound pulse back into an electrical pulse called an "echo." The echo then passes back through the matching network into the receiver where it is amplified and detected. The envelope of the pulse is then applied to the vertical deflecting plate of the oscilloscope. If the medium is a liquid or gas then metallic reflecting surfaces must be placed in the path of the wave normal to the direction of propagation. Pellam and Squire (1947) have made successful measurements of the velocity of compressional waves in liquid helium. They used a metallic reflecting surface which could be adjusted to the desired distance which measurements were being made.

The ratio of total distance traveled by the wave to the time difference between echoes, as measured with the oscilloscope, gives the velocity. If the sound attenuation in the medium is small, several echoes will be received and the measured time differences, averaged over the several echoes, will lead to a precise value for the round trip travel time.

If accurate measurements are to be made using this technique, then the duration of the r.f. pulse should be small, i.e., of the order from ½ to about 4 microseconds. This requires that high radio frequencies be used so that there will be a sufficient number of r.f. cycles and sufficient energy in the pulse to produce a detectable signal. The frequencies used are in the 5 Mc/sec to 100 Mc/sec range. The band width of the receiver must be broad enough to accommodate the pulse width used. The bandwidth BW is related to the pulse duration by the approximation $BW = \frac{2}{\delta}$, where δ is is in microseconds and BW is in Mc/sec.

It is not practical to use a quartz crystal having a resonance higher than about 15 Mc/sec because the very thin quartz plates resonating above this frequency are fragile and susceptible to fracture. If it is desired to use a very high frequency, say 60 Mc/sec, then a 15 Mc/sec crystal driven on its fourth harmonic may be used as the electromechanical transducer.

If sound measurements are to be made in solids then the quartz plate should be rigidly bound to the face of the solid. The binding material must form as thin a layer as possible between the quartz and the solid sample. Several successful binding agents have been suggested in the literature. For room temperature measurements Huntington (1947) has successfully used phenylsalicylate. The solid and the phenylsalicylate should be heated to about 45 degrees C in an oven and one or two drops of the salicylate applied to the top face of the solid. The quartz crystal is then properly centered and held in position by resting a smooth faced weight atop the quartz until the phenyl-salicylate has cooled and solidified.

The quartz crystals must be plated or sputtered with a thin conducting film of gold or silver. This film should be continuous over both faces and the edges of the quartz. Since the two electrical contacts must be made on one face of the quartz a thin non-conducting ring must be cut or etched out of the conducting film. The electrical contacts may be either press-spring fingers or a concentric spring contact arrangement as shown in Figure 2.

In the low temperature range from room temperature down to about 130 degrees Kelvin, ordinary stop-cock grease has been used successfully as a binding agent. Due to the different rates of contraction between the quartz transducer, the binding agent and the solid, sufficient strains may set in as the temperature is lowered to break the quartz away from the solid. When this occurs measurements are no longer possible. If the solid is a single crystal of the alkali-halide type the strains may become great enough at low temperature to crack the solid (Galt, 1948).

ULTRASONIC VELOCITIES IN METALLIC BERYLLIUM

At the Rice Institute Low Temperature Laboratory measurements of the velocity of longitudinal waves in beryllium were made from room temperature down to 23 degrees Kelvin in the helium cryostat. Also preliminary measurements with transverse waves were made down to 80 degrees Kelvin with a stop-cock grease binding agent.

These measurements were made at a frequency of 10 Mc/sec. An X-cut, ¾ inch diameter, 10 Mc/sec quartz crystal was used as the electromechanical transducer to produce longitudinal waves. The transverse waves were produced by a Y-cut quartz.

A plot of the velocity as a function of temperature is given in Figure 3. At zero degrees centigrade the velocity of longitudinal waves came out

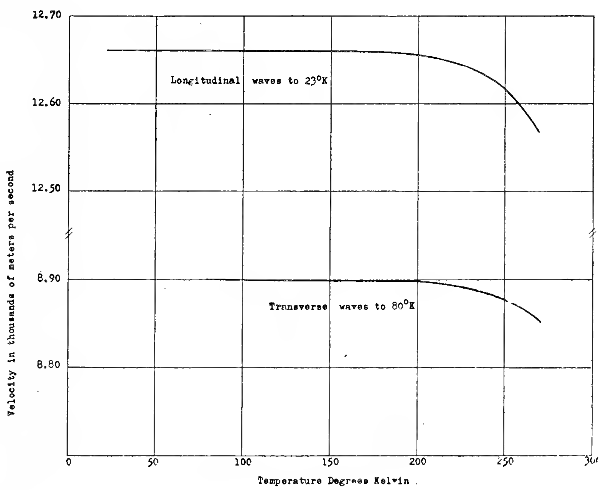

Fig. 3

to be 12,570 meters per second. This corresponds to a wavelength of 0.1257 cm at the frequency used. Since the investigation in beryllium is being continued these results are not considered final and it is expected that improvements in accuracy and measurements at still lower temperatures will be made.

MECHANICAL PROPERTIES

The beryllium sample used in these experiments was not a single crystal and the grain structure was not known. In general, however, the grain structure has a negligible effect on the velocity of longitudinal and transverse waves but does affect the attenuation (Roth, 1948). For the purpose of computing the elastic moduli the beryllium sample has been assumed to be homogeneous and isotropic.

The equation for the propagation of a disturbance in a homogeneous isotropic solid is

$$\rho\frac{\partial^2 s}{\partial t^2} = \frac{E}{2(1+\sigma)}\left[\nabla^2 s + \frac{1}{(1-2\sigma)}\text{grad div } s\right] \quad (1)$$

where s is the vector displacement, β is the density, E and σ are respectively

Young's modulus and Poisson's ratio. This equation is independent of co-ordinate system.

Since the end faces of the solid sample are flat and the direction of propagation is normal to these faces it is convenient to use the Cartesian co-ordinate system. The vector displacement s may then be written in terms of its x, y, z components.

$$s = iu + jv + kw \tag{2}$$

With a plane wave travelling in the x-direction the partial derivatives with respect to y and z vanish, so that equation (1) may be written in terms of the components of the vector displacement.

$$\rho \frac{\partial^2 u}{\partial t^2} = \frac{E(1-\sigma)}{(1+\sigma)(1-2\sigma)} \cdot \frac{\partial^2 u}{\partial x^2} \tag{3}$$

$$\rho \frac{\partial^2 v}{\partial t^2} = \frac{E}{2(1+\sigma)} \frac{\partial^2 v}{\partial x^2} \tag{4}$$

$$\rho \frac{\partial^2 w}{\partial t^2} = \frac{E}{2(1+\sigma)} \frac{\partial^2 w}{\partial x^2} \tag{5}$$

The component of the vector displacement s in the x-direction is u, so that equation (3) is the well known expression for a longitudinal wave with velocity.

$$v_l = \left[\frac{\rho(1+\sigma)(1-2\sigma)}{E(1-\sigma)}\right]^{1/2} \tag{6}$$

$$v_t = \left[\frac{2\rho(1+\sigma)}{E}\right]^{1/2} \tag{7}$$

The modulus of compression k and the shear modulus μ are related to E and σ by the equations

$$k = \frac{E}{3(1-2\sigma)} \qquad \mu = \frac{E}{2(1+\sigma)}$$

so that equations (6) and (7) may be written

$$v_l = \left[\frac{k + 4/3\,\mu}{\rho}\right]^{1/2} \tag{8}$$

$$v_t = \left[\frac{\mu}{\rho}\right]^{1/2} \tag{9}$$

The values of k, μ and Young's modulus at any temperature may then be calculated from the measured velocities. Figure 4 shows the variation of these moduli with the temperature from 270 to 80 degrees Kelvin. The modulus of compression k is the reciprocal of the adiabatic compressibility k_s. The variation of k_s with the temperature is shown in Figure 5.

At 270° the adiabatic compressibility is 1.03 x 10^{-12} cm^2 per dyne. Bridgman (1927) obtained values for the isothermal compressibility of beryllium using his piezometer on two different samples. On one sample the isothermal compressibility was 8.85 x 10^{-13} cm^2 per dyne at both 30° C and 75° C. On the other sample it was 9.0 x 10^{-13} cm^2 per dyne. Assuming that

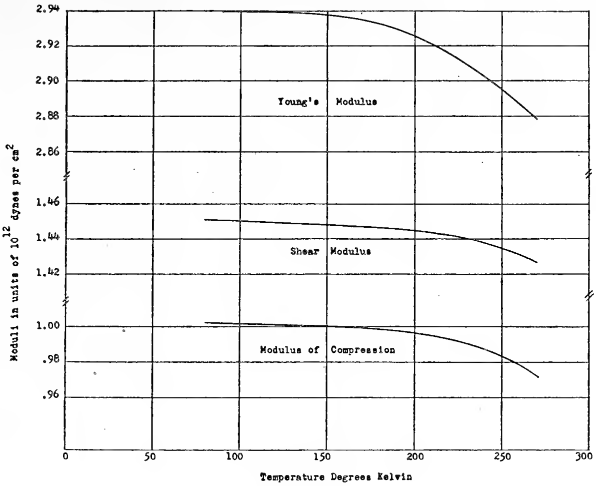

Fig. 4

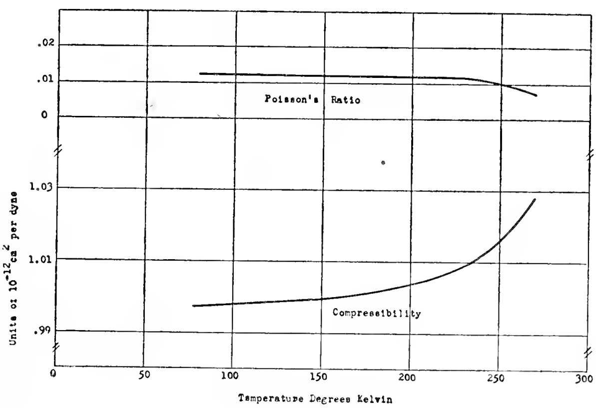

Fig. 5

the adiabatic and isothermal compressibilities are approximately equal, these results differ from Bridgman's by 10 to 15 percent.

Poisson's ratio may be obtained by dividing equation (6) by equation (7) and solving for σ. This leads to

$$\sigma = \left[\left(\frac{v_l}{v_t}\right)^2 - 2\right] \Big/ \left[2\left(\frac{v_l}{v_t}\right)^2 - 2\right]$$

Poisson's ratio is also plotted in Figure 5. Its value is in the neighborhood of 0.01 in this temperature range. This low value results because of the high relative velocity of the transverse waves and because the ratio of v_l^2 to v_t^2 is just slightly greater than 2. For most metals Poisson's ratio is 1/3 to 1/4, becoming equal to 1/2 at the melting temperature. The Poisson's ratio must therefore increase from the low value at 270° K shown in Figure 5 to the value 1/2 between 270° K and 1350° C. which is the melting point. Further work on the investigation of beryllium at higher temperatures is planned.

ACKNOWLEDGEMENT

The author takes this opportunity to thank Mr. R. F. Blunt, Mr. W. F. Love, and Mr. Nelson Skomal (all of the Rice Institute Low Temperature Laboratory) without whose assistance the experiments could not have been performed; and to thank Dr. C. F. Squire, who suggested the problem, supervised the experiments, and assisted in interpreting the data. This work was supported by the joint program of the Office of Naval Research and the Atomic Energy Commission.

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THE DISINTEGRATION OF CARBON BY DEUTERONS *

G. C. Phillips
The Rice Institute

A study has been made at the Rice Institute of the nuclear reactions occurring when C^{12} is bombarded by deuterons. The deuterons were accelerated with the Rice Institute Van de Graaff generator of improved resolution. Carbon targets were prepared by depositing thin layers of ceresin wax, or by cracking benzene, on silver disks. These targets were made thinner, for energy loss of deuterons, than the energy width of any of the observed nuclear levels (resonances).

The reactions studied were

$$(1) \quad {}_6C^{12} + {}_1D^2 \longrightarrow {}_7N^{14} \longrightarrow {}_6C^{*13} + {}_1H^1 - 0.52 \text{ Mev}$$
$$ {}_6C^{13} \longrightarrow {}_6C^{13} + \gamma \text{ (31 Mev)}$$
$$(2) \quad {}_6C^{12} + {}_1D^2 \longrightarrow {}_7N^{14} \longrightarrow {}_7N^{13} + {}_0n^1 - .282 \text{ Mev}$$
$$ {}_7N^{13} \longrightarrow {}_7C^{13} + e^+ + \mu + 1.26 \text{ Mev.}$$

The gamma rays in reaction (1) have been found to have about 3.1 Mev. The positron emitting ${}_7N^{13}$ accompanying reaction (2) has a half life of 10 minutes.

Reaction (1) was studied by means of the 3.1 Mev. gamma rays. A Geiger counter was placed beside the target and the number of gamma-rays per incident deuteron was determined as a function of the bombarding deuteron energy. Resonance yields were observed at 0.91, 1.16, 1.30, 1.435 and 1.73 Mev. These resonances had cross sections of 0.215, 0.255, 0.293,

* This work was supported by the joint program of the Office of Naval Research and the Atomic Energy Commission.
1. **Bennett, Bonner, Mandeville, and Watt.** Phys. Rev. **70**: 882 (1946)
2. **J. R. Risser.** Ms.
3. **Bennett, Bonner, Hudspeth, Richards and Watt.** Phys. Rev. **59**: 781 (1941)
4. **Bonner, Evans, and Hill.** Unpublished data.

0.457, and 0.735 Barns (10^{-24} cm^2) respectively. These indicate excited states in the $_7{}^*N^{14}$ intermediate nucleus at 11.04, 11.25, 11.37, 11.49, 11.74 Mev. above the ground state. The measured widths of these levels were 200, 200, 70, 6.3, and 300 kev. It is interesting to note that the 6.3 kev wide level at 11.49 Mev is the narrowest known deuteron excited level.

Reaction (2) was studied first by means of the positrons from the $_7N^{13}$. It is to be noted that a positron accompanies each neutron emitted. Since it was discovered that the neutrons are not spherically symmetrical about the deuteron beam while the relatively long lived $_7N^{13}$ will emit positrons isotropically, the number of positrons emitted into any known solid angle after ceasing a bombardment gives immediately the total cross section for the production of neutrons into the whole sphere about the target. The $_7N^{13}$ was prepared by bombarding a thin pure carbon target on a silver foil for two half lives of the $_7N^{13}$ (20 minutes) and recording the number of deuterons that struck the target. The target was then removed from the vacuum system and placed over a thin window Geiger counter that counted the positrons going into it with almost 100% efficiency. From the known number of carbon atoms/cm^2, the numer of deuterons, the observed counting rate for the positrons at the cessation of the bombardment, the known solid angle of the Geiger counter, and the decay constant $\lambda^{-1} = \frac{600 \text{ seconds}}{\log_e 2}$, the total cross section for neutrons was determined. These data were taken as a function of bombarding deuteron's energy. Resonances were found at 0.91, 1.16, 1.30, 1.63, and 1.73 with widths of 200, 200, 70, 150, and 70 kev and cross sections at maximum of 0.085, 0.110, 0.139, 0.139, and 0.160. It is to be noted that there is no resonance for reaction (2) corresponding to the narrow gamma-ray resonance at 1.435 Mev. Also it appears that there is no counter part to the 1.73 Mev gamma-ray resonance for the neutrons but rather a level just to either side of it.

The angular distributions of the neutrons of reaction (2) have been studied at nine energies: 0.775, 0.891, 0.991, 1.16, 1.20, 1.26, 1.35, 1.55, and 1.72. These angular distributions were determined by means of a hydrogen-filled proportional counter which was rotated about the beam from 0° to 160° in 15° steps in the laboratory coordinates. The counter subtended ± 12°. The counter system was biased to count no gamma-ray ionization, but only protons recoiling from the fast neutrons and possessing more than 150 kev. The data so obtained were converted to the center of mass coordinate system in which the $_7{}^*N^{14}$ is at rest and the numbers of neutrons per deuteron corrected for the variation of the counter efficiency with neutron energy and for the change in the solid angle subtended at the target by the counter in the c.m. system. These data showed large asymmetries for the number of neutrons into unit solid angle at the various angles. In particular for 1.26 Mev deuterons, five times as many neutrons are produced at 160° as are produced as 0°. Attempts are being made to fit these distributions with legendre functions and perhaps learn something of the angular momentum of the characteristic states of $_7{}^*N^{14}$. A more complete presentation of these data and their discussion will be presented in the Physical Review in the near future.

THE FLAME PROPAGATION VELOCITIES OF AIR-PROPANE MIXTURES IN A CONTROLLED TURBULENCE BUNSEN BURNER[1]

H. J. Buttner[2], F. W. Bowditch[3] and W. W. Floyd[4]
Purdue Research Foundation
Purdue University, W. Lafayette, Indiana

DEFINITION

In this paper the writers follow the recommendation made by a panel of the subcommittee on combustion (National Advisory Committee for Aeronautics) as outlined at the meetings on The Fundamentals of Combustion at the Applied Physics Laboratory, John Hopkins University, Silver Spring, Maryland, March 17 and 18, 1947, to the effect that the rate of progress of the combustion zone of a flame be referred to as the **flame propagation velocity.** This term as used herein is, therefore, identical in meaning with the **burning velocity** of Lewis and Von Elbe (1943), the **transformation velocity** of Fiock, Burke & Grummit (1943) and the **normal combustion velocity** defined by Jost (1946) as "the velocity with which the border surface between burned and unburned gases moves, relative to unburned gas at rest in immediate proximity to the combustion surface."

LAMINAR FLAME PROPAGATION VELOCITIES

Bunsen (Bone and Townend, 1927) was the pioneer in the determination of the speed of flame. His flash-back method, however, was not accurate. It was Gouy (1879) who made the first refined determinations of the propagation velocity of a Bunsen type flame. He measured the volume rate of flow through the port and the area of the cone of flame, dividing the volume rate of flow of the unburned gases by the area of the cone of flame to obtain the flame propagation velocity. Many subsequent workers have used the Gouy procedure or some modification of it to measure propagation velocities of flames.

Lewis and Von Elbe (1943) found that in a Bunsen flame the propagation velocity is highest at the rounded tip of the upright cone, decreases sharply from this tip downward, reaching a constant value which obtains over almost the entire lateral surface, and drops to zero at the base of the cone.

Using Mache's relation (1918),

$$p_u - p_b = \Delta p = \rho_u S_u^2 \ (\rho_u/\rho_b - 1)$$

Von Elbe and Mentser (1945) determined propagation velocities, S_u, of oxyacetylene flames from measured pressures of the unburned gas, ρ_u and the burned gas, ρ_b, and thermodynamically calculated ratios of the unburned to the burned gas densities, ρ_u/ρ_b; the values obtained agreed well with those found from flame cone dimensions.

Lewis (1947), applying the important relation of Mallard and Le Chatelier for the velocity of a combustion wave in an air-fuel mixture as a function of the temperature gradient from the burned to the unburned gas (Mallard and Chatelier, 1883), and making the reasonable approximation that the rate of rise of temperature from a point in the gas where ignition occurs to another point where burning is complete is constant, obtained the equation

$$S_u = \frac{\mu}{c_p \rho} \ \frac{(T_b - T_{ig})}{(T_{ig} - T_u)} \ \frac{(1)}{(x_b)}$$

(where S_u is the propagation velocity; μ the coefficient of heat conductivity;

1 This research was jointly sponsored by the Office of Naval Research and the Bureau of Aeronautics under Project SQUID.

2 Professor of Automotive Engineering.
3 Research Fellow.
4 Professor of Chemistry.

c_p the heat capacity at constant pressure; ρ the density; T_u the initial, T_{ig} the ignition, and T_b the final temperature of the mixture; and x_b the thickness of the burning gas layer between the points of ignition and the complete burning). All of the quantities in this equation except T_{ig} are measurable or calculable. The equation makes it possible, therefore, to determine ignition temperatures from flame propagation velocities and heat conductivity and capacity data.

TURBULENT FLAME PROPAGATION VELOCITIES

Few data are available concerning the propagation of flames in turbulent gaseous mixtures. Damkohler (1940) made use of the Guoy method to determine the flame propagation velocities of propane-oxygen mixtures in small Bunsen type burners in the range of Reynolds numbers of from 612 to 17,300 (referred to the inside diameter of the burner tube). He characterized a turbulent flame as having two distinguishable, though sometimes blurred, boundary surfaces of the combustion zone, an inner and an outer cone, which are relatively far apart. (The combustion zone of a laminar flame, it will be remembered, is a single, very thin cone, the inner and outer bounding surfaces of which practically coincide). He designated the inner cone as the locus of the fastest, the outer of the slowest combustion. He found the flame propagation velocity measured at the outer cone to equal that of an identical gaseous mixture flowing laminarly. The propagation velocity measured at the inner cone was twice that at the outer at a Reynolds number of 4000, three times the outer at a Reynolds number of 12,000, and three and one-half times the outer at a Reynolds number of 17,300. He regarded the ratio of the propagation velocity at the inner to that at the outer cone as a measure of the effect of the turbulence on the flame propagation velocity in his burner.

EXPERIMENTATION

The air-propane supply for the burner used in the present work is shown in Figure 1. Propane from high pressure tanks was passed successively through two diaphragm control valves in series (for pressure reduction) , 1150 cubic inches surge tank (for damping fluctuations), a calibrated rotameter (for rate of flow measurement), a needle valve (for fine adjustment of rate of flow), and into a mixing chamber, where it was mixed

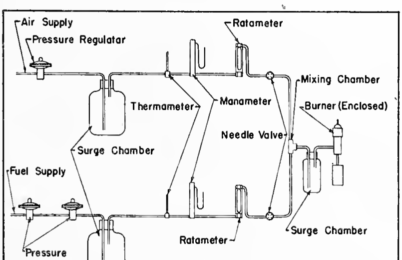

Fig. 1.- FUEL & AIR SYSTEMS

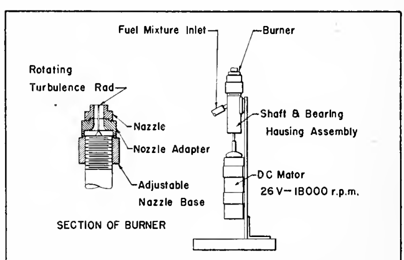

Fig. 2.– TURBULENCE CREATOR & BURNER

with air. The air inlet was similar to that for the propane, except that only one diaphragm valve was used to reduce the air pressure. The propane and air were mixed in the T-shaped mixing chamber and the mixture conducted through a final surge chamber to the burner.

The burner is shown diagramatically in Figure 2. The turbulence creator was an 0.086 inch diameter rod which was rotated by a small high speed motor (located beneath the burner) capable of revolving up to 18,000 revolutions per minute at 26 volts. The main body of the burner consisted of a housing containing two ball bearings for the rotating rod. A conical shield protected the combustible gaseous mixture from the turbulent eddies produced by the ball bearings. The burner nozzle, a contracting jet type, was composed of three main sections, as follows: (a) a vertically adjustable base, (b) an adapter, and (c) the nozzle proper. By use of the adjustable base, the burner could be raised or lowered with respect to the rod. The nozzle was variable as to size and shape.

Attempts were made to determine the dimensions of the combustion zone using in turn (a) the optical set-up of Garside, Forsyth and Townend (1945), (b) a Fastax motion picture camera equipped with Eastman Super XX or colored film, and (c) the schlieren system used by van de Poll and Westerdijk (1941). None of these gave turbulent flame photographs of sufficient clarity of detail.

For our purpose, simple, direct photography proved to be the most successful procedure. An Agfa Compur camera, mounted on a vertically adjustable stand and placed as close as possible to the flame, was used to make the photographs. The port of the burner was illuminated by an electric lamp placed on the side of the burner opposite to the camera. All of the light from the lamp bulb was excluded from the flame under observation, only the port of the burner being silhouetted in front of the camera lens. The camera was placed at such a height that the burner port, so illuminated, appeared as a horizontal straight line. Agfa Isopan film was exposed 1/7 second and developed with Eastman D-11, a highly contrasting developer. The negatives were magnified 10.5 times and the enlarge-

TABLE 1

The flame propagation velocities of 22:1 air-propane mixture at various speeds of rotation of the rod in the burner throat

Speed of Rod (R. P. M.)	Flame Propagation Velocity (in./sec.)
0	14.1
1320	14.3
3200	14.7
5940	16.6
6750	17.6
7280	18.3

As the speed of the turbulence-creating rod was increased from zero to 7280 revolutions per minute, the flame propagation velocity increased from 14.1 (laminar value) to 18.3 inches per second, an increase of 30% of the laminar flow value. All of the flame propagation velocities reported here are, of course, average values, obtained by consideration of all parts of the combustion cone.

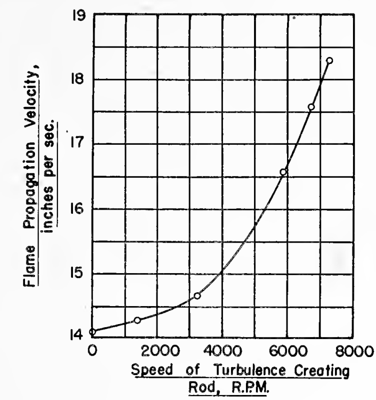

FIG. 3. FLAME PROPAGATION VELOCITIES OF AN AIR-PROPANE MIXTURE FOR VARIOUS ROTATOR SPEEDS.

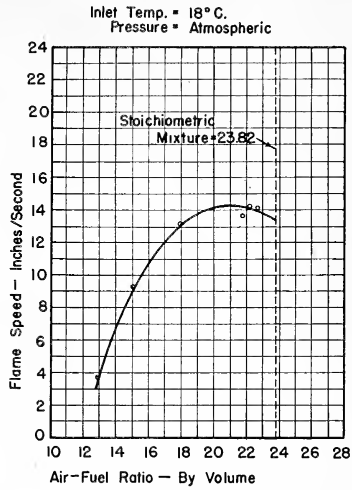

Fig. 4.—FLAME VELOCITY OF PROPANE

ments printed on Kodabromide F-4 enlarging paper. Under these conditions, the outline of the flame appeared sufficiently distinct in the photograph to permit the measurement of the cone area.

FLAME PROPAGATION VELOCITIES IN THE CONTROLLED TURBULENCE BUNSEN BURNER

Rotating the rod of this burner did not result in the formation of a visible two cone combustion zone such as characterized Damkohler's rapidly flowing oxy-propane mixtures. When the rod was rotating, the combustion zone still appeared as a single cone; it was less distinct and flatter and had its tip more noticeably rounded off than when the rod was not rotating, but the outline was clear enough so that the cone area could be determined by the method of graphical integration.

A mixture of 22 volumes of air and 1 volume of propane at 18° C. and atmospheric pressure was burned at the rate of 7.5 cubic inches per second while the rod was rotated at from zero to 7,280 revolutions per minute. The diameter of the burner port was 0.422 inches. The flame propagation velocities at various speeds of rotation of the rod are recorded in Table 1 and shown graphically in Figure 3.

For comparison, laminar flame propagation velocities were determined for air-propane mixtures of other proportions in the burner; that is, the mixtures were burned and the velocities determined without rotating the turbulence creator. The unburned mixtures were at 18° C. and atmospheric pressure. The propagation velocities of the various mixtures are plotted in Figure 4. The propagation velocity of a 13:1 mixture was 4 inches per second, that of a 21:1 mixture was 14.3 inches per second; the latter was the maximum velocity for a laminar air-propane mixture in this burner. The maximum velocity of flame propagation is characteristic of mixtures slightly richer than the stoichiometric (23.82:1). Propagation velocities of stoichiometric air-propane mixtures could not be measured in the Purdue controlled turbulence burner; for any mixture leaner than 22:1 the flame blew off the port.

The flame propagation velocity of a laminar air-propane mixture burning in a Bunsen type burner evidently depends markedly on the air-propane ratio and somewhat on the specific character of the burner. As the air-propane ratio in the controlled turbulence burner was increased from 13:1 to 21:1 the flame propagation velocity increased from 4 to 14.3 inches per second, an increase of 250% of the lower velocity.

The flame propagation velocity in the maximum speed air-propane mixture measured in Corsiglia's (1931) burner was 11.4 inches per second, while that in Smith's (1937) burner was 17 inches per second. An average of six determinations of the propagation velocities of about 20.9:1 air-propane mixtures made in Smith and Pickering's (1936) 0.96 centimeter diameter burner is 13.3 inches per second. The variation in the most widely different of these results of other investigators, presumably due to specific burner characteristics, is 50% of the lowest propagation velocity obtained.

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A SEARCH FOR A BASIS OF PEACE AND HUMAN SECURITY

H. M. Holm, Th. D.
McMurry College
Abilene, Texas

CAUSES OF WAR

We know that if a physician is not able to diagnose a certain disease and find the cause, he is not able to effect a cure. That pertains to epidemics as well as to individual illness. Some five hundred years ago people assembled in churches to pray to God to stop an epidemic which made it more widespread. As over against that it happened within my experience that a city doctor, as president of the board of health, ordered all churches to be closed, and they were closed for three months. The first step was to stop the epidemic from spreading; the second step was to find the cause so as to prevent its origin. It seems to me as if it is necessary to use a similar method in our efforts to stop the outbreak of war.

We finally succeeded in stopping the last war after it had done an immense amount of damage. Now let us consider the causes of this war so as to find a way to prevent another.

In the first place they had deep roots in the past. We have been told that these roots are purely of economic nature. Europe, we were told, was divided into "have" and "have not" nations, and that the latter could not see any reason why they should not have what other nations had. There is a great deal of truth in this. Undoubtedly a weighty reason for Germany and Japan starting the last war was that they wanted free access to raw material, free control of commerce and more land where they could put their surplus population.

However the root of the cause of the last world war goes much deeper than to economic problems. We have to search for it in the fields of sociology and philosophy. We might say that the upper and narrower layer is economics, next layer is sociology and the real, underlying layer is philosophy, as follows:

Economics

Sociology

Philosophy (Political
(Moral
(Religious

Of course it is true that the immediate cause of the war, started by Germany and Japan, was that they wanted material advantages. It was simply analogous to highway robbery among individuals. "I want what you have. If you do not hand it over, it is not my fault that I have to kill you."

A somewhat deeper cause, however, was the unsatisfactory living conditions in those countries. The German people were fascinated by Hitler's promise that they would not have to live a cramped life in the future but would have a glorious time rolling in the meadows of France and the Scandinavian countries, living in other people's beautiful homes and enjoying their delicious food. This, as we know, actually happened for a brief period of time.

And yet we have to search still deeper for a cause of the last war, and we find it in German philosophy, and that did not originate with Hitler. He was not a cause but a product.

Germany, as we know, was not a united nation until 1870. But approximately forty years before that time, some German philosophers started to promote the doctrine that the Germans were superior to other people in the world. This idea flared up soon after the empire was formed in 1870. Hambro (1942) says:

"From 1874, and on, Treitsche was lecturing at the University of Berlin and thundering in the Reichdag; his popularity was enormous and his influence even more so. He coolly declared that since Germany will never be able to understand the world, the world must be conquered and reformed so that it will be able to conform to German thought. But he doubted that other nations were reformable and later wrote that Germany can never have peace with the world because to the German way of thought the world is a foreign world which cannot be reformed, but can only be overthrown." He was the first great open exponent of the mailed-fist doctrine; he claimed that Germany's destiny was to conquer and dominate the world and to hold the nations in thralldom (the geographical predestination). There is no other force than the will of the State, and a Germany "rightly constituted can recognize no earthly power, and might is right only when a German wields the sword." Germany must make it a duty to employ traitors in the enemy state for its own interest," and "every good German is a latent, and when opportunity arises, an active spy."

Again quoting Mr. Hambro:

"Treitsche had preached war, but he was no mystic and poet. Nietzsche proclaimed war as a religious commandment:

"Ye have heard men say: Blessed are the peacemakers; but I say unto you: Blessed are the war-makers for they shall be called, if not the children of Yahweh, the children of Odin who is greater than Yahweh (the Jewish and Christian God)."

Nietzsche and other philosophers developed the doctrine of Superman, and that of Germans were "herrenvolk," and because they were superior to others they were destined to rule the world. The professors studied this philosophy and taught it to future school teachers studying at the universities; they again taught this doctrine in schools and colleges.

Personally I do not believe that this idea had matured to such an extent in Germany before World War I that Wilhelm II actually intended to conquer the world. I do not believe that he was as bad as he was pictured during that war. It seems as if he was a tool in the hands of the "Junkers," or military leaders.

We know that Germany actually tried to establish a democracy after the first world war. But they had no background for a democracy and were not able to handle it. It seems to me as if that was the time when the strong nations might have prevented World War II.

As the bottom fell out of Germany's economic system, most Germans, including many intellectuals, surrendered their faith in the future and took an attitude like this: "Our dream will never be realized. We are not even able to handle our own affairs."

Then up popped an enthusiastic paper hanger, a former corporal, and said: "I can realize your dream. Just hand it over to me."

Even the best Germans would take this attitude: "Let him try; it cannot be any worse than it is now."

When Hitler then took over the rulership he began to undermine the moral and religious philosophy represented by the church. He appointed as chief bishop a military man and told him to cut out all the passages in the Bible teaching kindness, love and humility. The philosophers had prepared the ground for the rejection of the teachings of The Prince of Peace. Hitler announced that there was no other God but Germany itself. And, as Führer, Hitler was to decide what was right and wrong. We know about his unusually effective educational system, his political planning, and how he succeeded in getting the Powers to help him to build up an army and navy by which he would be able to conquer the world.

A few far-seeing men predicted what this would all lead to, but their voices were not heard. There was a great deal of money involved in the process of rearming Germany. Even laborers opposed any effort to stop it. Dr. Bradley of Chicago said that he heard Winston Churchill lecturing in England (before he became Prime Minister) pleading with tears that shipments of war material to Germany be stopped, but even the laborers booed him out. Chamberlain supported Hitler for two reasons: 1. He feared Russian Communism. 2. He held investments in Germany.

Now it is my conviction that England, France and the United States could have prevented World War II at an early stage, if they had known how, and if the people would have been willing to follow such wise leadership. But most of the people in those countries were blinded by economic gain and a wrong philosophy.

The German people themselves could have prevented both World War I and II. But ethnocentricism blocked their vision, hindered them from seeing a thing or cause from different angles and prevented them from understanding the difference between right and wrong.

About four hundred Lutheran ministers with their leader, Pastor Niemüller, constituted noble exceptions. Hitler said to Niemüller in substance, "You take care of your religious people and prepare them for Heaven and let me handle civil and political affairs." The minister's reply was: "Nein Herr Hitler, Nein. You will hear from me when you do something wrong." That was exactly the attitude of the Hebrew prophets. So when Niemüller condemned Hitler's doings from his pulpit and said: "Gott ist mein führer," the soldiers took him down from the pulpit and put him in the concentration camp where he remained for eight years.

If fifty million Germans instead of four hundred had taken a stand with Niemüller, there would have been no World War II and no such miserable conditions for the Germans as they are in today. In other words, the majority of the population of an aggressive country can, if they want to, prevent a world catastrophy. The common people of Sweden prevented war with Norway in 1905, and what they did in Sweden others can do in other countries; but after a country is attacked there is nothing else to do but to put up a defense. In other words, freedom-loving people will rather die than be slaves.

Now, only four years after the world blood-bath we are facing the possibility of its repetition.

It might not happen. Some say it cannot happen within the next ten years. Others again, with expert knowledge, tell us that it might happen any time. Hence we gain nothing by ignoring the possibility. As we know what the results will be, we ought to move heaven and earth in order to prevent it.

Considering the present situation we find some similarities between the dominating Russian philosophy and the philosophy promoted in Germany before the last war. Both deny the existence of God and reject the teachings of Jesus. Lenin wrote that Communism does not recognize the existence of any God of any kind. I heard a minister from Moscow say that any one who joins the Communist party must swear a solemn oath that he does not believe in any God. Consequently there is no standard of right and wrong. The dictator alone sets the standard. When at the beginning of his rule Stalin issued an order that some people be killed his secretary said, "But Mr. Stalin, this is wrong." The reply was, "I decide what is right and wrong."

Dr. Dunnington, a friend in the ministry, said that when he was in the courthouse in a certain city in Russia a couple came in to get a marriage license. The clerk of court, a lady, asked the man, "Are you able to support a wife?" Before the man could answer, the woman said, "You don't need to be concerned about it. I am collecting alimony from five husbands." The license was granted immediately.

The political situation of today, however, is different from the situation before and during the last war. It does not seem as if the aim of Stalin and Russia is to make all nations subject to the country of Russia. Today we are face to face with a world-wide revolutionary movement, and it did not originate in Russia.

The Communist Manifesto issued by Karl Marx and Frederick Engels about a hundred years ago in England has not been an active threat to world peace until the last two or three years. It is interesting to notice that of the ten points in the Manifesto, the following three have been adopted either in whole or in part by the democratic countries including the United States:

"2. A heavy progressive or graduated income tax.

7. Extension of factories and instruments of production owned by the State; and bringing into cultivation of waste lands, and the improvement of the soil generally in accordance with a common plan. (Adopted in part).

10. Free education for all children in public schools. Abolition of children's factory labor in its present form. Combination of education with industrial production, etc."

If Communism would confine itself to working for the gradual adoption of the ten points, it does not seem as if that alone would constitute a threat to world peace. But Marx and Engels went far beyond that in "The Manifesto." They say: "The Communists distain to conceal their views and aims."

They openly declare that their ends can be attained only by the forcible overthrow of all existing social conditions. Let the ruling classes tremble at a Communist revolution. The proletarians have nothing to lose but their chains. They have a world to win.

Working men of all countries, unite!"

Lenin and Stalin have said plainly that the method of reform is altogether too slow. They say that Communism can not and must not be satisfied until every government in the world is overthrown and the proletarians become rulers. Both of them admit, however, that while proletarians are not able to rule, the problem is easily settled by dictatorship.

The method of Communism differs from that of Hitler in that it does not wish to conquer one country after another by sheer military power. It wants to win the common people by propaganda. It would seem reasonable that the aim of Communism would be to win a majority in every country and in that way establish a Communist government. But Stalin in his book on Leninism says that Communism cannot wait for a majority in any country. He says that the method is to get a number of Communists large enough to be able to overthrow the government and then issue orders to the population to obey. Obedience must be secured by force. It is well known that this is the method they have used in Russia and the satellite countries.

We are told by authorities that Russia can easily take one country after another in Europe beginning with the small ones, if each country stands alone. If this should occur we know it would be disastrous to the United States.

It is not difficult to understand why Communism is attractive to the proletariat in middle and southern Europe. Millions of people are crying for bread, clothes and shelter. Communism promises these things to everybody. Many people, who have had little or no liberty in the past, prefer bread.

When Dr. George Mecklenburg, of Minneapolis, travelled in Germany before we entered the war he said to a German who praised Hitler, "But you have no liberty here." The reply was, "Liberty! What do we care about liberty? We want bread. Hitler gives us bread."

In addition to the supply of bread Communism promises the starving people to dominate the country and to obtain the money that the rich people have.

It is natural that such a program should appeal to the starving people in middle and southern Europe, but why and how is it that Communism is making considerable progress in the United States?

One reason probably is the widespread fear of war with Russia. It is natural to think that if we could have Communistic government in the United States we would have everlasting peace with Russia. But would that include human security? It seems to me that our fear of war would just be converted to fear of being killed by order of the government. Another reason why Communism appeals to the common people of the United States is that most of our wealth is in the hands of a few, and that there is an unreasonable difference in the income of a few in almost all occupations as over against the income of the rank and file.

Of course we know that people occupied in manual labor are better off in the United States than in any other country. We also know that they are better off than they have ever been. But when they look at those who have earned millions and billions from the laborer's toil they cannot help but think that they have not received the proper share of their earnings.

This discrepancy does not only exist between capital and labor. Cuber and Harper (1948) give a list of the highest earningsof about half a dozen individuals in a number of occupations. Let me quote a few:

"The ministry	$ 15,000.00
Teaching (not including income from textbooks)	15,000.00
Teaching (including income from textbooks)	50,000.00
Medicine and surgery	200,000.00
Law	300,000.00
Business management	400,000.00
Acting	400,000.00
Entrepreneurial ability	2,000,000.00"

This information gives us a vivid picture of the unwillingness of the most fortunate people in most occupations to share with their fellowmen. Even in the ministry, whose mission it is to promote brotherly love, some members of the profession are accepting salaries far beyond their needs, while their fellow ministers do not receive enough for a comfortable living. It seems as if brotherly love and sharing is not practiced by all who preach it! However, steps have been taken in the right direction by the establishment of minimum salaries.

The picture that I have tried to present of the situation we are in is very inadequate, yet I think it might help us to see what Communism stands for and why it is making great progress in the world. We may not know all about it, but when we know its ultimate aim as definitely expressed by Marx, Lenin and Stalin we can see how extremely difficult it is to make lasting peace with Communism. It seems as if we either have to accept it or fight it. The crucial question then is, how should we fight it?

Do we have to go to war with Russia in order to stop the progress of Communism? We have been told what the results of another world war will be. Some experts have also told us that if we go to war with Russia immediately we have good prospect of winning. A few have said that that would be the best thing to do.

Suppose that we win a war with Russia, without being destroyed ourselves, what would we have on our hands? In the first place a devastated Europe in a condition many times worse than now. In the second place a country to control several times the size of our own. How could we prevent Communism from rising again?

One of our popular magazines stated when the Third Party, called the Liberal Party, made up its platform one point was to make terms with Russia and let Stalin have what he wants. If that should be realized we would be just where we were when Hitler made his demands. Finally nothing could stop him but war. That would be so now.

I do not consider myself qualified to state how we can avoid war with Russia, and if I were qualified I would be too insignificant to be heard.

However, in our search for a basis of peace and human security it seems to me as if the following principles and methods, some of which have been suggested by eminent experts, would be helpful:

1. That all nations of the world support the organization of the United Nations and accept its findings and decisions as we in the United States accept the decisions of our Supreme Court.

2. As Russia does not seem to be willing to take the attitude the other nations should form a solid compact to stand together in case of invasion or Communistic revolution.

The idea once promoted by the late French statesman Briand, and others, of a United Europe like the United States is not practical or feasible. The small nations take great pride in handling their own affairs, and some of them do it better than some large nations, only they are not able to defend themselves against overwhelming military powers.

The idea of a society of nations is not new as Immanuel Kant developed such a plan about two hundred years ago. It is high time to put this plan into practice.

3. The Atlantic Pact would serve as an effective means of protection and prevention of war.

4. A program should be worked out by which the common people of all non-Communist countries would bee given an opportuity to earn enough money to provide a comfortable living. I realize that such a plan would be extremely difficult to work out, but it would be a safe bulwark against Communism. When the common people are satisfied they have no desire for Communism, and Russia neither would nor could attack a country where there is no base. In this respect it seems as if the Marshall plan is a step in the right direction. Unless we help Europe to get on her feet, a large number

of people will prefer bread to freedom just as the Germans did under Hitler.

5. In the United States it seems to me as if we ought to use different methods in fighting Communism than we have used and are using. We use the method of abuse, condemnation and persecution. History shows that movements, religious or otherwise, have been strengthened by being persecuted. Why not try the method of adoption of the good points or of revamping our social and economic system? It would mean great sacrifice to the people at the top of our social and economic ladder; but it certainly would be better even for them than revolution and the rule of Communism. After all, the common people are in majority, and history shows that they can get what they want, if the situation comes to be desperate. A boiling kettle will burst if the steam has no outlet. We only need to mention the French Revolution of 1789 and the Russian revolution of 1917. When the proletarians get the upper hand with dictatorship there is no place to stop, and there is no mercy for the rich.

Suppose now that we could get a system by which the owners of our large industries would share their profits with the employees so as to make the latter feel that they were partners in the business and were receiving approximately what they were earning? The owners would perhaps not be able to pile up billions of dollars, but they should be allowed a considerable margin of profit. They certainly would be better off than under Communistic rule when they would have nothing, as abolition of private property is a definite goal of Communism. Stalin explains, however, that any man will be permitted to keep the property that he has earned with his own labor, but that it will be taken away from the wealthy because the laborers have earned it for them.

The cooperative movement is a step in the right direction. Its aim is not to do away with competition and private enterprise but to make it strong enough to control prices of merchandise and wages of labor. As such it would make a contribution to the general welfare and satisfaction of the common people so that they would not want Communism. Hence it would act as a strong factor in the promotion of permanent peace and human security.

The cooperative movement worked wonders in Sweden and Denmark before World War II. Great professors of economics in our eastern universities went to Sweden to study the system there. Upon his return one of them wrote a book entitled: *Sweden the Middle Way*. It was a way between Communism and capitalism. The common people did not take any money away from the rich, as in Russia, but banded themselves solidly together and entered into competition with the capitalists. The result was that in those countries the common people (especially farmers and laborers) controlled the market prices, improved social conditions and controlled the politics of their country. The kings and the governments were also on the side of the common people. Of course it is much easier to make such a system work in a small country than in a large country where capitalism is as strong as in the United States.

As a summary I shall try to put up a few main guide posts for use in our search for a basis of peace and human security:

1. It is difficult, almost impossible, to make lasting satisfactory terms with Russian Communism as its ultimate aim is revolution and overthrow of government.

2. Abusing, misrepresenting and fighting Communism by persecution and war will fail to bring peace and human security.

3. The philosophy of pacifism, that no country will have war that is not prepared for it, broke down during the last war. Pacifistic countries were overrun by the enemy. They were simply exposed to the robbers.

4. Reforming and revamping the social and economic system in non-Communistic countries so as to provide security and satisfaction to common people would be a strong safeguard against revolution and war.

5. It is not just that able and faithful people in various occupations and professions should only be allowed a bare existence-earning while others with little or no more preparation and ability live in luxury and abundance. Hence a maximum earning should be established, the surplus to be divided among the people in the lower brackets according to faithfulness, preparation and ability.

6. We should keep in mind that Communism is an atheistic as well as a revolutionary movement. Its dominance would not only do away with freedom of belief and freedom of worship but consequently would cause the downfall of moral ideals.

It is to be deplored, even from the point of view of sociology and morality, that atheistic elements in our country have succeeded in securing a ruling of the majority of the Supreme Court, forbidding the teaching of religion and the Bible on public school time. Religious and moral instruction of the young is a stronger element contributing to human security in any country than laws, punishment or force from the outside.

I know that compulsory religious education is impossible in the United States; but in the Scandinavian countries, where that has been practiced for several hundred years, the crime element is low and the general morality is high.

What I have written contains only a few suggestions for a search for peace and human security. Neither one person nor a small group would be able to bring about the changes that would make for such peace and security. It would take groups of experts to work out a plan in the first place. Then it would take a tremendous amount of propaganda and systematic education to win support and action on the part of the people. It seems as if we would have to use a regimentation method at least partly similar to that of Hitler. Some people turn thumbs down on any plan imposing on their personal freedom. But our present situation is such that if a definite plan is not worked out, and some desperate efforts are not made to put it in operation Communism will keep on gaining ground, and if it comes to dominate the world there will be little or no freedom for anybody.

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A 315 Halliday Ave.
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Texas Tech.
Lubbock, Texas

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Parks, Harris B. 43
Entomologist
A & M College
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Consulting Geologist
F Box 1860
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Prof. of Histology & Embryology
Dept. Anatomy, Med. Branch U of T
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202 Life Sciences Bldg.
V Stillwater, Oklahoma

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II Austin, Texas

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*Lundell, Dr. C. L. L41F49
Director, Texas Research Found.
F Box 43
II Renner, Texas

Moore, John I. 46L48
Box 551
Midland, Texas

McCullough, Tom L. L46
1502 Praetorian Bldg.
Dallas, 1, Texas

Sellards, Dr. E. H.
Geologist
U of T & Texas Memorial Mus.
IV Austin, Texas

Semmes, Dr. Douglas R.
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1701 Milam Bldg.
IV San Antonio, Texas

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Biology Teacher
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Teacher, S. W. Jr. Col.
P. O. Box 293
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Grad. Student, U of T
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Texas Liquor Control Board
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IV Houston, Texas

Bond, T. J. 43
Instructor in Chem.
819 James
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Boudrye, Mason R. 48
Asst. to Dean
1018 Blodgett
Houston, 4, Texas

Bradfish, Ford 46
2010 Ft. Worth Nat'l. Bldg.
IV Ft. Worth, Texas

Bullock, Henry Allen 48
Professor of Sociology
Prairie View A & M
III Prairie View, Texas

Burns, Dr. B. T. 46
John Sealy Hospital
II Galveston, Texas

Campbell, Joe R. 48
Professor A & M
Dept. Ag. Eco.
II College Station, Texas

Conzatti, Dr. C. 48
Botanist
Caxaca, Mexico

*Cory, Victor 29F30
Range Botanist
Box 619, S. M. U.
II Dallas, 5, Texas

Crouch, R. Pat 48
Student & Asst. Teacher
2418 7th St.
Lubbock, Texas

Crye, Delmer G. 48
Student
Box No. 125, McMurry College
Abilene, Texas

Cunningham, T. M. 48
Head, Social Science Dept.
324 Normal Ave.
III Denton, Texas

Daniel, R. H. 48
Botanist
Carrera 51, No. 53-12
Medellin, Colombia, S. A.

Davis, Dan R. 48
Teacher & Research, A & M
Dept. Ag. Eco. & Sociology
III College Station, Texas

Dawson, E. T. 41
Bio. Div. Texas G. F. & O. C.
Walton St. Bldg.
II Austin, 14, Texas

DeLoach, Rodney Roy 48
Pet. Eng. Student
1021 West Gray
IV Houston, Texas

Dinter, Henry Anton, Jr., 46
S 3001 Lasker Ave.
Waco, Texas

Dugand, Dr. Armando 48
Botanist
Herbario Nacional de Colombia
Instituto de Ciencias Naturales'
Bogata
II Colombia, South America

*Dyksterhuis, Dr. E. J. 45F49
Chief, Range Division
Soil Conservation Service
Post Office Bldg.
II Lincoln, Nebraska

Grace, Mrs. Victor Jr. 45
Teacher
Apt. 5E, 2635 Valentine Ave.
II New York, 58, N. Y.

Grant, Lester S. 46
P. O. Box 912
IV Midland, Texas

Gross, E. W. 47
P. O. Box 2447
Beaumont, Texas

Gurley, Irving M., Jr. 48
Advanced Student
905 Milby St.
IV Houston, 3, Texas

Halpin, R. B. 48
Teacher, A & M
Dept. Agric. Eco.
II College Station, Texas

*Heflin, Bess 39F47
Teacher Home Economics
Texas University
III Austin, Texas

Herald, A. C. Jr. 48
1353 East 109th St.
I Los Angeles, 2, Calif.

Hopkins, J. Thomas 48
Oil Operator
209 Hopkins St.
Longview, Texas

Hubbard, Dr. Louis H. 40
President
Box 3925, TSCW Station
III Denton, Texas

Hubbard Wm. E. 46
Engineer
Box 2180
I Houston, Texas

Hunt, Robert L. 48
Teacher, A & M
Box 5777
III College Station, Texas

Irvin, Aldred Van 48
Teacher
Prairie View A & M
I Prairie View, Texas

Johnson, Sidney A. 47
Magnolia Pet. Co., P. O. Box 900
Dallas, Texas

*Lamar, Jule K. 45F46
S Dept. of Obstetrics & Gynecology
Univ. of Texas Med. Branch
Galveston, Texas

*Laubach, Paul J. C. F47
313 Vermont St.
Covington La.

Leonard, George J. 48
B. Sc. X-ray Tech.
838 Hot Wells Blvd.
II San Antonio, Texas

Lewis, Ray C. 47
S Houston Oil Co. of Texas
Box 2412
Houston, Texas

Livezey, Dr. Robert S. 46
Biology Dept., SHSTC
1211 W. 19th St.
Huntsville, Texas

Lungstrom, Leon G. 44
Student Grad. U of T
206 South Cedar
II Lindsborg, Kansas

Magee, Miss Marion T. 48
S Teacher, U of H
5405 Long Dr.
IV Houston, 4, Texas

Martinez, Prof. Macimo 48
Botanist
Calzada de la Piedad 665
Mexico D. F., Mexico

Mayo, E. H. 48
Dental Lab.
838 Hot Wells Blvd.
San Antonio, 10, Texas

Miranda, Dr. Faustino 48
Botanist
Herbario Nacional, Instituto de
Biologia
Casa del Lago de Cha Pultepec
Mexico, D. F., Mexico

Morazzani, A. 48
Div. Mgr., Well Surveying Corp.
Box 632
IV Midland, Texas

Muckelroy, Miss Deane 48
Advanced Student, U of H
144 Sims Drive
IV Houston, Texas

McAdams, Edna Mae 48
Teacher
1827 N. 6th St.
I Waco, Texas

McAnulty, William N. 48
Teacher
Sul Ross State College
IV Alpine, Texas

McCarley, W. H. 48
Grad. Student, Research Asst.
2616 Rio Grande
II Austin, Texas

McCarty, Faye A. 48
Teacher
314½ W. Mulberry
II Denton, Texas

Nelson, F. M. 47
Mining Engineer
No. 5 West Oak Dr. South
IV Houston, 6, Texas

Newcomb, William W., Jr. 48
Instructor
Dept. of Anthropology, U of T
III Austin, Texas

*Nichols, Dr. C. A. 37F39
Prof. of Education
S. M. U.
III Dallas, Texas

Nicol, David 48
Teacher of Paleontology, Geology
3801 St. Bernard St.
IV Houston 4, Texas

Norton, George H. 47
3637 Bryn Mawn Dr.
Dallas, Texas

Orr, Anne Estelle 47
P. O. Box 2205
Dallas, 1, Texas

*Poth, Dr. J. Edgar 45F46
Physician-Surgeon
Univ. of Texas Med. Branch
I Galveston, Texas

Powell, W. T. 48
Teacher, Sul Ross
Box 808
III Alpine, Texas

Raymond, Thomas W. 48
Asst. Prof. of Biology
S.F.A.S.T.C.
II Nacogdoches, Texas

Robinson, William E. 48
Teacher, Hillsboro Jr. Col.
P. O. Box 23, BU Station
I Waco, Texas

*Rust, W. M. Jr. 45F48
Geophysicist
P. O. Box 2180, Humble Oil Co.
I Houston, Texas

Samuel, William A., Jr. 48
Chemist
Prairie View A & M
I Prairie View, Texas

Schipper, Dr. Arthur L. 37
Biology Prof.
Dept. of Biology, Uni. of Notre Dame
II Notre Dame, Indiana

Schlader, Dr. Jerome B. 48
Dental Teacher
1200 Sante Fe St.
Corpus Christi, Texas

Scruggs-Carruth, Margaret 48
Insurance & Prof. S. M. U.
3715 Turtle Creek Blvd.
V Dallas, 4, Texas

Shaw, Emil G. 48
Teacher
East Texas State Teachers C.
II Commerce, Texas

Shaw, S. Fred 46
Consulting Mining & Pet. Eng.
301 Terrell Rd.
IV San Antonio, Texas

Shook, Ellen Louise 48
Lab. Instructor
Dept. of Geology, U of H
IV Houston, Texas

Smith, Garland Albert 48
Student & Geological Scout
641 Grape St.
IV Abilene, Texas

Spence, Harry M., M. D. 48
S Physician
4105 Live Oak St.
III Dallas, Texas

*Spencer, Dr. S. R. 38F47
Physics Dept., Baylor Univ.
821 Speight Ave.
I Waco, Texas

Steinicke, David G. 48
Sociology Teacher, A & M
F. E. Box 255
III College Station, Texas

*Stoker, Spencer 37F43
S Prof. of Education
Drawer B. TSCW
III Denton, Texas

*Street, W. E. 42F46
Dept. of Eng. Drawing, A & M
College Station, Texas

Taylor, Alfred 46
Research Biologist
Biochemical Institute
Austin, Texas

Thawley, Leonard 46
S 1408 W. Tennessee
IV Midland, Texas

Thornton, Wilmot A. 48
Student, U of T.
602 Elmwood Place
II Austin, Texas

Toole, Marion 39
Chief Aquatic Biologist
3401 Windsor Rd.
V Austin, Texas

*Upton, R. G. 38F46
Prof. of Biology
SFASC
Nacogdoches, Texas

Voss, Geraldine 48
Teacher
1211 Austin
I Denton Texas

Webster, Eugene B. 48
Teacher
220 N. Beard St.
II Shawnee, Oklahoma

Williams, D. W. 40
Head Dept. Animal Husbandry
A & M College
II College Station, Texas

Zenor, Hughes M. 48
Teacher
P. O. Box 7415
I Houston, Texas

GENERAL MEMBERSHIP 1949

Achterberg, George W. 47
S P. O. Box 1066
Sweetwater, Texas

Adam, Brother Wendel, C.S.C. 48
Instructor Biology
St. Edwards' Univ.
II Austin, 1, Texas

*Adams, Dr. Roy H. 44F46
Dean of College
Sam Houston State College
II Huntsville, Texas

Adams, O. V. 46
Div. of Eng., Texas Tech.
2905 Twentieth St.
III Lubbock, Texas

*Adriance, Guy W. 45F47
Prof. of Horticulture
II College Station, Texas

Agnew, Letha Alice 48
S Chemistry Teacher, High School
1207 Palm Dr.
I Corpus, Christi, Texas

Akin, Miss Berta 44
A Head Science Dept.
II Waskom, Texas

*Albers, Dr. C. Clarence 32F48
S Teacher of Pharmacy
A College of Pharmacy, Univ. Sta.,
II Austin, 12, Texas

*Albritton, Claude C. Jr. 37F40
3436 U. Blvd.
IV Dallas, 5, Texas

Allen, Mr. E. G. 46
Geologist
6745 Avalon Ave.
IV Dallas, 14, Texas

Allen, Mr. Ralph H., Jr. 49
Senior Biologist
Dept. Conservation
II Montgomery, Alabama

Allred, B. W. 46
Chief, Regional Range Div.
6405 Garland
Ft. Worth, 7, Texas

Altgelt, Ernest S. 48
S Consulting Engineer
Rt. 8, Box 252
San Antonio, Texas

Althaus, Henry O. 48
Science Teacher
Box 462
V Rosenberg, Texas

Ames, Mr. Edward W. 49
Consulting Geologist & Mining Eng.
A Box 828
IV Seguin, Texas

Anderson, Hulon N. 38
Supt. of Schools
Box 469
II Conroe, Texas

Anderson, Mr. Jack W. 49
Asst. Prof. Agriculture
1502 Ave. K.
II Huntsville, Texas

Anderson, Miss Laura 40
Biology Teacher
2401 Oakdale
Houston, Texas

Anderson, Dr. Robbin C. 47
Chem. Dept., U of T
Austin, Texas

Anderwald, Mr. Frank R. 48
Ranch Foreman
c/o Cutbirth Ranch
V Fresno, Texas

Anigstein, Prof. Ludwik 48
Prof. of Prev. Med.
A Univ. of Texas Med. Branch
II Galveston, Texas

Anthis, Mrs. Fay Wright 47
Head Home Eco. Div., W of H
3726 Cleburne
II Houston, Texas

*Armer, Sister Joseph Marie 30F
Biology Teacher
Incarnate Word College
II San Antonio, 9, Texas

Armstrong, Mr. George S. 47
Pres. George S. Armstrong & Co.
52 Wall St.
I New York, 5, N. Y.

Arnette, Mr. D. W. 33
Biology Teacher
2165 Swenson
II Abilene Texas

*Arnim, Dr. Sumter Smith 48F49
Dental Teacher (Restorative)
F Univ. of Texas Sch. of Dentistry
II Houston, 4, Texas

Arnold, Mrs. Betty Anne 46
Housewife
Arnold Ranch
II Ashland, Kansas

Arnold, Mr. D. Clayton 47
Atty. & Pet. Eng.
c/o Nat'l. Bk. of Tulsa
I Tulsa, Okla.

Ashmore, James 49
Research Chemist, S. W. Med. Col.
A 2211 Oak Lawn Ave.
I Dallas, Texas

Atkins, Mr. G. T. 47
S Sr. Engineer, Project Design Div.
A Box 183
I Highlands, Texas

Atkinson, Dr. Carroll 48
Formerly Dean of Men
A Southwestern University
III Georgetown, Texas

Austin, Mr. H. R. 47
Pres., M. W. Kellogg Co.
225 Broadway
I New York, 7, N. Y.

Avery, Mr. Paul C. 33
Asst. Plant Quarantine Insp.
A P. O. Box 31
II Mission, Texas

Bagwell, L. Raymond 47
6222 Gay St.
Houston, 9, Texas

Bailey, Mr. Orris G. 49
Super. Science & Math
2206 Brun
I Houston Texas

*Baird, Mrs. Gladys H. 32F40
Teacher
Box 228
III Huntsville, Texas

Baker, B. B. Jr. 49
Marine Biologist
II Rockport, Texas

Baker Mr. Leo L. 46
Pet. Engineer De Golyer & Mac Naughton
3118 Carlson
IV Dallas, 9, Texas

Bakke, W. E. 46
W. E. Bakke Oil Co.
119 Seeling Blvd.
IV San Antonio, Texas

Baldwin, Edward F. 49
S Export Representative,
Hughes Tool Co.
3963 Del Monte
Houston 19, Texas

*Baldwin, Dr. James W. 39F48
Prof. Education
Sutton Hall 219, Univ. Sta.
III Austin, 12, Texas

Balleisen, Charles Edward 49
Supt., Mech. Lab.
A S West Research
326 Ligstrum
I San Antonio, 1, Texas

Banck Leo J., S. M., 48
St. Marys' Univ.
San Antonio Texas

*Bantel, E. C. H. F30
Teacher of Civil Eng.
2307 San Antonio St.
I Austin, Texas

Barber, Walter W. 49
S Gen. Mgr., L. N. Dantzler Lumber Co.
IV Perkinston, Miss.

*Barkley, Dr. Fred A. 43F46
Prof. Extraordinario
A Miguel Lillo No. 205
II Tucuman, Arentina

*Barkley, Mr. William W. F47
Tech. Spec. In Welch Apparatus
P. O. Box 550
II Austin, 3, Texas

Barnes, Miss Adele 42
Science Instructor, Amarillo Col.
A 3006 Hughes St.
II Amarillo, Texas

Barnes, Mr. George G. 46
S Bakery Manager
1800-7 St.
II Pt. Arthur, Texas

*Barnett, Mr. D. G. 46F49
F Geologist Union Producing Co.
P. O. Box 711
IV Beeville, Texas

Barr, Dr. John Haddin 48
Assoc. Prof. Medicine
A 1018 Blodgett
II Houston, 4, Texas

*Barrow, Mr. L. T. 37F38
Chairman of the Board
A 3314 Chevy Chase Dr.
IV Houston, 19, Texas

Bartlett, Terrell 47
2700 Transit Tower
San Antonio, Texas

Battle, Jack L. 47
Humble Oil & Refining Co.
P. O. Box 2180
Houston 1, Texas

*Baughman, Mr. J. L. 46F46
Chief Marine Biologist
Box 867
V Rockport, Texas

Begeman, Mr. M. L. 46
A Dept. of Mech. Eng., U of T
I Austin, Texas

Bell, John S. 46
Humble Oil Co.
Box 2025
I Tyler, Texas

Beninson, Dr. Joe 48
Med. Student, Research Assoc.
1409 Broadway
II Galveston, Texas

Bennett, Roy 49
Student
226 So. 3rd St.
I Abilene, Texas

*Berkman, Dr. Anton H. 30F40
Biological Sciences Teacher
F Texas Western College of U of T
II El Paso Texas

Bertram, Alexander Carl 47
S 6403 Edloe
Houston, 5, Texas

Bertschler, G. W. 33
Teacher of Physics
4906 Alamo Dr.
I Galveston, Texas

Bible, Mr. John L. 46
Pres., Tidelands Exp. Co.
A 2626 Westheimer Rd.
IV Houston, Texas

Bierberdorf, Frederick W. (Dr.)
Research Assoc. Found App. Res.
A 3500 W. Woodlawn Dr.
II San Antonio, Texas

Biesele, Prof. R. L., Jr. 47
Prof. & Head Dept. Electrical Eng.
3241 Amherst
I Dallas, 5, Texas

Bishop, Harold C. 49
S Independent Oil & Gas Operator
915 City Nat'l. Bank Bldg.
IV Houston 2, Texas

*Black, James Harvey M. D. 46F49
F 1405 Med. Arts Bldg.
II Dallas, Texas

Blair Dr. W. Frank 47
Asst. Prof. Zoology
A Zoology Dept., Univ. of Texas
II Austin 12 Texas

Blanchard, A. 49
Charge Engineering Dept.
Schlumberer Well Surveying Corp.
I Box 2175, Houston 1, Texas

*Blank Horace R. (Dr.) 43F46
Assoc. Prof. Geology
Dept. Geology, A. & M.
IV College Station, Texas

Blucher, Mr. Conrad M. 45
S Civil Engineer
A 245 Rosebud
I Corpus Christi, Texas

Blum, Mr. E. H. 47
S Vice-Prs. & Gen. Mgr. Crude Oil Prod.
P. O. Box 2819
IV Dallas, 1, Texas

Bodemann, Dr. Elsie 35
Biology Teacher, ETSTC
A 2401 Bryan St.
II Commerce, Texas

*Boner, Dr. C. P. 34F34
Teacher of Physics
F P. O. Box 1, Univ. Station
I Austin, Texas

Bonner, Louis 44
Box 2180
IV Houston, Texas

Bounds, Miss Nell 49
Assoc. Prof. of Physics, Hardin Col.
2014 Tenth St.
I Wichita Falls, Texas

Bowman, W. F. 46
Consulting Geologist
709 Esperson Bldg.
IV Houston, Texas

Box, E. O. 49
Prof. Physics
A Box 1066
I Commerce, Texas

Boyle, James W., Jr., M. D. 47
Shiner Clinic, Physician & Sur.
II Shiner, Texas

Boyle, Mr. Walter J. 46
Pet. Geologist
1207 Milam Bldg.
IV San Antonio, Texas

ter Braake, Mr. A. L. 44
Pres. & Gen. Mgr. Tin Proc. Co.
P. O. Box 1461
IV Texas City, Texas

Braden, Albert H., M. D. 46
S Physician, Allergist
A 1704 Crawford St.
II Houston, Texas

*Breeder, Dr. C. M. Jr. 49F49
Chmm. Dept. Fishes & Aquatic Bio.
F American Museum of Natural Hist.
II New York, 24, N. Y.

Briggs, Frank 46
Engineer, Houston Oil Field Mat.
Box 2589
I Houston, Texas

Briggs, Geo. Waverly 47
First Nat'l. Bank
Dallas, Texas

*Brindley, Dr. Paul 40F
Prof. Pathology
F 925 Ave. B.
II Galveston, Texas

Briscoe, Rose 47
S D. & H. Chevrolet Co.
303 East Third St.
Pecos, Texas

*Brison, Fred R. 48F48
Horticulture Teacher
Horticulture Dept. A. & M.
II College Station, Texas

Broad, Mr. Thomas D. 47
Architect, Engineer, & Planner
618 Res. Loan Life Bldg.
V Dallas, 1, Texas

Broadhurst, William Leslie 49
Geologist, U. S. Geological Sur.
302 West 15th St.
IV Austin, Texas

Bronaugh, Richmond L. 46
Instructor Geology, Baylor U.
A 1919 Sanger Ave.
IV Waco, Texas

Brown, Mr. Bryce C. 48
Asst. Prof. & Assoc. Curator
Strecker Museum, Baylor Univ.
II Waco, Texas

Brown, Mrs. Ella 48
520 Quincy (East)
San Antonio, Texas

*Brown, Mrs. Meta Suche 36F
Assoc. Prof.
Dept. of Agronomy, A & M
II College Station, Texas

Brown, Norris 39
S Dist. Rep. Harshaw Chem. Co.
3020 Lubbock St.
I Ft. Worth, 4, Texas

Brown, Sidney O. 35
Biology Research Lab.
Box 4849
II College Station, Texas

Brown, Dr. Walter V. 48
Asst. Prof. Botany
A Dept. of Botany, U. of T.
II Austin, 12, Texas

Brownscombe, E. R. 46
1420 El Campo
IV Dallas, 18, Texas

Bryant, Dr. M. D. 44
Egg Dehydration
Austin College
II Sherman, Texas

Buchan, R. C. 46
Box 2180
IV Houston, Texas

Bullen, Charles Victor (Mr.) 44
Prof. & Head Dept. of Elec. Eng.
E. E. Dept., Texas Tech.
I Lubbock, Texas

Buls, Mr. William C. 49
Geology Student
Box 461
IV Richmond, Texas

Burgess, Dr. B. Edward 49
DDS
2418 Travis St.
II Houston, 6, Texas

Burgess, J. W. 47
Box 763
Dumas, Texas

Burgin, Mr. C. J. 48
Chief Foulbrood Insp.
Dept. of Entomology, A & M
II College Station, Texas

Burkhart, H. Ray 49
Asst. Prof. A. H.
A. H. Dept. Texas Tech.
II Lubbock, Texas

Burnett, Earl 49
Asst. Prof. of Agronomy
108 Ave. W.
V Lubbock, Texas

Burton, Mr. George E. 46
Geologist Sun Oil Co.
6th Floor Turner Hotel
II Gainesville, Texas

Burton, William H. 49
College Teacher
P. O. Box 24, S. U. Sta.
III Georgetown, Texas

Butts, Mr. James A. 46
Dist. Eng. Tidewater Assoc. Oil
Drawer 152
I Kilgore, Texas

*Bybee, Hal P. 30F34
Prof. Geology, U. of T.
A 1406 Enfield Rd.
IV Austin 21, Texas

Byron, C. W. 46
S 1402 M. Esperson ''g.
IV Houston, Texas

Callender, Mr. R. E. 43
Extension Service
Box 254, A. & M.
V College Station, Texas

Calohan, Mr. William F. 47
Geologist, Consulting
414 Sames-Moore Bldg.
I Laredo, Texas

Calvin, Dr. D. Bailey 49
Prof. of Bio. Chemistry
Med. Branch U. of T.
II Galveston, Texas

*Campbell, Mr. Kenneth P. 46
Metallurgist, Sheffield Steel Corp.
P. O. Box 3129
I Houston, Texas

*Campwell, Dr. Thomas Nolan 48F49
S Assoc. Prof. Anthropology
F Anthropology Dept., U. of T.
III Austin, 12, Texas

*Capt. Miss Lucille 30F46
Teacher, Mary Hardin Baylor
A Box 476, Baylor Station
II Belton, Texas

Carlton, D. P. 46
Geologist
856 Humble Bldg.
IV Houston, Texas

Carman, Dr. Katharine W. 40
S Geologist, Carman & Hanagan
933 Michigan Ave.
IV Evanston, Ill.

*Carrico, James L. 36F46
Professor of Chem.
1922 Chestnut (West)
I Denton, Texas

Carter, D. V. 46
5930 Hudson St.
I Dallas, Texas

Cashin, Mr. D'Arcy M. 49
S Consulting Geologist & Pet. Eng.
2018 Nat'l. Standard Bldg.
IV Houston, 2, Texas

Cavitt, Hugh, (Mr.) 46
Plant Quarantine Inspector
606 E. Fillmore
V Harlingen, Texas

Cerno, Virginia 49
Teacher, Edgewood Sch.
504 E. Guenther
II San Antonio, Texas

*Chambers, Dr. William T. 36F41
Geography Teacher & Head Dept.
Box 214 N. St. Station
IV Nacogdoches, Texas

*Cheney, Mr. M. G. F36
S Oil Geologist & Producer
F Box 846
IV Coleman, Texas

Cheney, Mr. Monroe G. Jr. 49
A Physics Teacher
I Coleman, Texas

Cherry, Mr. Robert G. 48
Tax Economist
Dept. Ag. Eco. & Soc.
III College Station, Texas

Claiborne, Ray 46
3417 Bellaire Dr. So.
Ft. Worth, Texas

*Clare, Sister Mary 45F
Biology Prof.
Our Lady of the Lake College
II San Antonio, Texas

*Clarence, Sister Mary 34F
Chemistry Prof.
A Our Lady of the Lake College
I San Antonio, 7, Texas

Clark, H. Smith (Mr.) 46
S Geologist & Eng.
2307 Warner Rd.
I Ft. Worth, Texas

*Clark, R. T. Jr. 42F46
Abilene Christian College
Abilene, Texas

Clark, S. W. 48
Manager Agri. Dept.
A 1002 Second Nat'l. Bk. Bldg.
II Houston, 2, Texas

Clark, Mr. William K. 48
Grad. Student & Teaching Fellow
Dept. of Zoology, U. of T.
II Austin, Texas

Clark, Willis H. 44
Teacher
Box 3927, TSCW Station
I Denton, Texas

Clawson, Chas. H. 49
Social Science Inst.
Amarillo College
III Amarillo, Texas

Clements, John H. 49
Head Physics Dept.
A 2209 Taylor St.
I Commerce, Texas

*Cline, Dr. Joseph L. 34F34
S Meteorologist
231 W. 12th St.
Dallas, Texas

*Clough, Dr. George O. 41F41
Director of Extension
Box 624, S. M. U.
III Dallas, Texas

Cockrum, Dr. E. D. 49
Lab. & Med. Director
107 New Haven Dr.
II San Antonio, Texas

Cole, C. Taylor 46
611 W. Missouri St.
IV Midland Texas

Collette, Allan, M. D. 48
Director U. of H. Health Service
3801 St. Bernard St.
II Houston, Texas

Colquitt, Landon A. 48
Teacher
2124 Fairmont Ave.
I Ft. Worth, 4, Texas

Connell, W. B. 49
Supt. Hot Wells Public Sch.
328 Avondale
San Antonio, Texas

Cornelius, L. W. 39
Tester in Lab.
3228 Iowa St., Station A.
I Baytown, Texas

*Cortes, Mr. Henry C. 46F48
S Asst. Mgr. Exp. Dept.
F P. O. Box 900, Magnolia Pet. Co.
IV Dallas, Texas

Cosey, Glenn 49
Biological Sciences
1952 West Concho St.
San Angelo, Texas

Cowan, Frank A. 44
Army
2201 Schulle Ave.
II Austin, Texas

*Crichton, Mr. Jack A. 48F49
Pet. Engineer & Geologist
F 1000 Continental Bldg.
IV Dallas, Texas

Cross, Dr. Joy Barnes 44
Research Assoc. in Bacteriology
1128 Church St.
Galveston, Texas

Crosthwait, Dr. W. L. 43
Surgeon, Crosthwait Clinic
A 107-S. 18th St.
II Waco, Texas

Crowell, John H. 46
3416 Ella Lee Lane
I Houston, Texas

Culberson, Hon. Olin 44
S R. R. Commissioner
Tribune Bldg.
III Austin, Texas

Culli, Mr. George Jr. 45
Super. Shellfish Sanitation
Box 49
I Corpus Christi, Texas

Dake, Laurence F. 46
1106 Main St.
IV Rollo, Miss.

*Damon, Dr. H. Gordon 37F40
S Assoc. Prof.
A Box 1561, Univ. Station
IV Austin, Texas

Dante, John H. 46
3527 Runnymede Pl. N. W.
IV Washington, 15, D. C.

Daugherty, Mr. F. M. Jr. 49
Marine Biologist
Box 512
II Rockport, Texas

Davidson, Floyd F. 46
Box 122, Baylor Univ.
Waco, Texas

Davidson, Mr. K. B. 46
Div. Pet. Eng.
P. O. Box 840, Humble Oil Co.
IV Wichita Falls, Texas

*Davis, Dr. J. DeWitte 43F46
Education Teacher
T/C Arts & Industries
III Kingsville, Texas

Davis, L. Irby 39
Box 988
Harlingen, Texas

Davis, Lea 49
Asst. Prof. Biology
1506 Boise Ave.
V Commerce, Texas

Davis, Mr. Morgan J. 46
Director, Humble Oil & Ref. Co.
A Box 2180
IV Houston, Texas

Davis, S. F. 34
Chemistry
John Tarleton College
Stephenville, Texas

Davis, William K. (Mr.) 48
Biology Instructor, SWTSC
No. 4 Riverside
II San Marcos, Texas

Day, Willard L. 46
S Box 2252
IV Houston, 1, Texas

Dean, John E. 49
Assoc. Prof. Electrical Eng.
Texas A. & I.
I Kingsville, Texas

*DeFord, Mr. Ronald K. 38F39
S Prof. Univ. of T.
A Univ. Station, Box 1652
IV Austin, 12, Texas

*DeGolyer, Dr. Everette Lee 46F49
Geologist, De Golyer & MacNaughton
F 1000 Continental Bldg.
Dallas, Texas

Delaney, Dr. J. J. 44
Pres. Schreiner Inst.
Schreiner Institute
III Kerrville, Texas

Delaphane, Dr. Walter H. 48
Economics Dept., A. & M.
Box 2245
III College Station, Texas

Dennis, Homer A. 40
Prof. of Math
Lamar Junior College
I Beaumont, Texas

Denny, Miss Grace 33
1104 Houston Ave.
Crockett, Texas

Dillon, Lawrence S. (Mr.) 48
Zoology Instructor
Biology Dept., A. & M.
II College Station, Texas

*Doak, Dr. Clifton C. 30F33
S Head Biology Dept.
F Box B, F. E., A. & M.
II College Station, Texas

*Dobie, J. Frank 30F35
S Author
702 Park Place
Austin, Texas

*Dobson, Dr. W. J. 40F47
S Asst. Biology Prof.
A Box D, A. & M. Annex
II College Station, Texas

Doherty, Mr. W. T. 46
S Fidelity Oil & Royalty Co.
A 2010 2nd Nat'l. Bk. Bldg.
IV Houston, Texas

*Donaghue, David 44F46
Ft. Worth Nat'l. Bank Bldg.
Ft. Worth, Texas

Donahue, Dr. Roy Luther 39F46
Extension Agronomy, A. & M.
Box 5763
V College Station, Texas

*Dooley, Dr. Thomas P. 48F49
Head Dept. of Natural Sciences
F Prairie View A. & M.
II Prairie View, Texas

*Dotterweich, Dr. Frank H. 45F49
Director Div. of Engineering
Dept. of Engineering, Texas A. & I.
I Kingsville, Texas

Doughtie, Mr. Venton L. 46
Dept. M. E.
A Univ. of T. Dept. Mech. Eng.
I Austin, Texas

*Duncan, Dr. Wallace E. 44F47
Head Dept. of Chemistry, Sul Ross
A Box 848
I Alpine, Texas

*Dunlap, Dr. A. A. 39F46
Chief Div. of Plant Pathology
F Dept. of Plant Physiology & Path.
II College Station, Texas

*Dunn, Floyd W. 46F
Dept. of Chem. Univ. of Colorado
Boulder, Colorado

Durkee, Joseph B. 48
Physician & Surgeon
4507 Gaston Ave.
II Dallas, 4, Texas

Durkee, Robert R. 46
3727 Gramercy
Houston, 5, Texas

Dyme, Dr. Harry Chaim 48
Chemist, Foundation App. Research
A Box 2296
I San Antonio, 6, Texas

Dzilsky, Thomas E. 48
Student, U. of H.
c/o The Milwhite Co., Inc.
IV 801 Cotton Exch. Bldg.
Houston, Texas

Eads, Dr. Richard A. 49
Chemistry, U.C.C.
Chemistry Dept. Univ. of Corpus C.
I Corpus Christi, Texas

Eaves, Charles D. 49
History Prof.
Texas Tech.
III Lubbock, Texas

Ebaugh, Frank W. 39
A 428 S. Patton
I Jacksonville, Texas

Eble, P. W. 46
1033 Cedar Hill
I Dallas, 8, Texas

*Eby, Dr. J. Brian 32F32
S Consulting Geologist
1404 Esperson Bldg.
IV Houston, 2, Texas

Eckel, Mr. John E. 46
Vice-Pres. Oil Center Tool Co.
P. O. Box 3091
IV Houston, 1, Texas

Eckles, Dr. Howard H. 49
Marine Fisheries Biologist
450-B Jordon Hall
Stanford, Calif.

Edmonds, A. G. 45
Teacher
Box 4872
I College Station, Texas

*Edwards, George L. 44F46
Gen. Mgr. Brownsville-M. Bridge Co.
Box 93
III Brownsville, Texas

Eilers, Mrs. William 49
Chmm. Soc. Sci., San Angelo Col.
2 N. Oakes St.
III San Angelo, Texas

*Elliott, Dr. Frederick C. 39F47
S Dean & Prof. Texas Dent. Col.
F 1018 Blodgett
II Houston, 4, Texas

Elliott, John E. 46
S 108 W. 15th St.
IV Austin, Texas

Ellis, Mrs. Emma Huck 39
S Office Emp. Karotkin Kur. Co.
P. O. Box 76
II Nordheim, Texas

Ellison, Joseph E. 48
Teacher
Prairie View A. & M.
I Prairie View, Texas

Ellsworth, F. Leslie 49
Student, Museum Worker
Witte Museum
II San Antonio, Texas

Engelhardt, H. T., M. D. 49
Physician
P. O. Box 2180
II Houston, 1, Texas

Engeling, Gus A. 49
Wildlife Botanist, G. F. & O. C.
Box 4836
I College Station, Texas

Erck, Lisette 49
R. N. & Bacteriologist
1419 North Flores St.
II San Antonio, Texas

*Eskew, Mr. Cletis T. 43F46
Dean of Administration
Biology Dept., Hardin Jr. Col.
II Wichita Falls, Texas

Etheredge, Mr. O. F. 45
Wildlife Biologist, G. F. & O. C.
Box 444
II Alpine, Texas

*Etheridge, Dr. T. H. 44F
Dean, Prof. Education
A Box 359, Sul Ross State College
III Alpine, Texas

*Ettlinger, Dr. H. Joseph 43F46
Prof. of Math
F P. O. Box 1512, Univ. Station
I Austin, 12, Texas

Everts, Arthur A. 47
Pres., Arthur A. Everts Co.
1616 Main St.
I Dallas, 1, Texas

*Ewalt, Dr. Jack 46
Prof. Neuro-Psychiatry
Med. Sch. Univ. of Texas
III Galveston, Texas

*Ewing, Dr. Paul L. 46F46
Prof. Pharmacology & Toxicology
A Dept. Pharmacology, Med. Branch
U. of T.
II Galveston, Texas

Fan, Dr. Paul H. 48
Teacher
Geology Dept., U. of H.
IV Houston, 4, Texas

*Fancher, Dr. George H. 44F47
Prof. Pet. Engineering
201-B, P. E. B., U. of T.
I Austin, 12, Texas

*Felsing, Dr. W. A. 34F
Prof. of Chem. U. of T.
Dept. of Chem., U. of T.
I Austin, 12, Texas

Fenn, Ivan J. 46
318 Crestwood Dr.
IV Houston, 7, Texas

Ferguson, Alice 49
Asst. Biology Prof.
ETSTC
II Commerce, Texas

Ferguson, Mr. Herschal C. 49
S Consulting Geologist
935 M. Esperson Bldg.
IV Houston, Texas

Ferrando, Al 46
942 Milam Bldg.
IV San Antonio, Texas

Fertsch, Dr. Pauline 46
S Instructor
Dept. of Psychology, U. of T.
I Austin, Texas

*Fetzer, Lewis Wm., M. D. F25
Physician
1107 Sarasota Circle
Dallas, Texas

Fiedler, Evelyn A. 49
Science Instructor
Texas Lutheran College
I Seguin, Texas

Finegold, Sidney M. 49
Med. Student
320 Ninth St.
II Galveston, Texas

Fisher, Mr. Gordon H. 46
Chief Pet. Eng. Gulf Oil
P. O. Drawer 1290
IV Ft. Worth, Texas

Fitzgerald, Dr. Norman D. 46
Oil Producer
602 Riverside Blvd.
IV Abilene, Texas

Flesh, David 46
Geologist & Engineer
P. O. Box 491
IV Jefferson, Texas

Fletcher, Henry T. 46
Cattle Breeder
II Marfa, Texas

*Fletcher, Herbert H. 39F40
S Printer & Bookstore Operator
403-05 Fannin at Preston
Houston, Texas

*Fletcher, Dr. Robert K. 35
Retired
Route 1, Box 302
II Garland, Texas

*Floyd, L. P. 38F38
5301 T. C., North Texas Teachers
I Denton, Texas

Flury, Alvin 48
Student, Univ. of Texas
514 Joan of Arc
III Austin, Texas

*Focht, John A. 46
Univ. Station
I Austin, Texas

Folk, Mr. Stewart H. 48
Geologist. DeGolyer & MacNaughton
c-o Petroleos Mexicanos
Av. Juarez, 95, Of. No. 208
Mexico, D. F., Mexico

Follett, Dr. W. I. 49
Acting Curator of Fishes
Golden Gate Park
San Francisco 18, Calif.

Ford, Albert L. 49
Box 3686, T.S.C.W. Station
I Denton, Texas

Ford, Mr. David O. 48
Inventor
201 Dullnig Ct.
I San Antonio, 10, Texas

Forgeron, H. S. 46
S P. O. Box 1575
I Midland, Texas

Forsyth, F. Howard (Dr.) 49
Prof. of Economics
Trinity Univ.
III San Antonio, Texas

Forsyth, Dr. John W. 47
Asst. Prof. Biology
A Biology Dept., TCU
II Ft. Worth, Texas

Franks, Robert M. 46
S Pet. Geologist
A P. O. Box 970
II Alice, Texas

*Freeman, Dr. W. W. 44F
Prof. & Dir. Visual Aid
Box 680
III Commerce, Texas

Frey, Dr. C. Elmer 39
Psy., Oak Pl. Sanitarium
A 2204 Baldwin
III Houston, Texas

*Fuller, Mr. Frederick D. 30F30
Supr. Feed Inspectors
F 200 S. Congress Ave.
II Bryan, Texas

Fulton, Dr. MacDonald 49
Assoc. Prof. of Bacteriology
A 3801 St. Bernard St.
II Houston, 4, Texas

Furr, Mr. R. J. 47
Director, Texas Safety Service
808 N. Marsalis
I Dallas, 8, Texas

*Gaines, Newton 33F33
Prof. of Physics
Dept. of Physics, TCU
I Ft. Worth, Texas

Gardner, Edgar J. (Mr.) 46
Consulting Geo.
820 Staley Bldg.
IV Wichita Falls, Texas

Gardner, Dr. Frank J. 46
Chief Geologist, Reinhart Oil News
P. O. Box 1208
IV Dallas, Texas

*Gaupp, Dr. Frederick E. 48F48
Asst. Prof. History & Govt.
Box 362, S. U. Station
III Georgtown, Texas

Gee, Dr. Lynn L. 49
Prof. Bacteriology
Box 4708
II College Station, Texas

*George, William O. F46
Geologist
F 4004 Duval St.
IV Austin, Texas

Gerundo, Michele (Dr.) 48
Pathologist & Microbiologist
1305 Broadway
II Lubbock, Texas

*Getzendaner, F. M. 30F36
S Pet. Geologist
I Yellville, Arkansas

Gibson, J. E. 49
Retired Teacher
307 Hawthorne
Houston, 6, Texas

*Gidley, William F. 32F32
Pharmist
3105 Grooms St.
II Austin, Texas

Gilliam, R. A. 47
1123 Cedar Hill Ave.
Dallas, 8, Texas

Gilmore, Kathleen K. 46
5818 Cedar Springs
IV Dallas, Texas

*Gingrich, Dr. Wendel D. 35F36
Prof. Bacteriology
F Univ. of Texas Med. Col.
II Galveston, Texas

Glass, Mr. J. T. 44
Instructor, Vocational Ag.
II Box 527, Athens, Texas

Glazener, Mr. W. C. 47
Director, Wildlife Res.
920 E. 53rd
II Austin, Texas

*Glick, Perry A. 39F40
Asst. Entomologist
Box 1218
II Waco, Texas

Glick, Walter R. 49
Head, Soc. Sci. Div.
Texas Wesleyan College
III Ft. Worth, Texas

Glimp, Thomas Jr. 47
Box 517
Menard, Texas

*Godsey, John T., Sr. 44F
Teacher
Science Dept., Hillsboro Jr. Col.
II Hillsboro, Texas

Goedecke, Otto 49
S Cotton Merchant
II Hallettsville, Texas

*Goldich, Dr. Samuel S. 39F40
205 Pillsbury Hall, Univ. Minn.
IV Minneapolis, 14, Minnesota

Goodman, Mrs. J. M. 38
Biology Teacher
811 E. 27th
II Bryan, Texas

*Goodwin, Dr. R. C. 35F41
Head Dept. Chem., Dean Arts & Sci.
A Chem. Dept. Texas Tech.
I Lubbock, Texas

Gorirossi, Flora 49
Research Asst.
401 N. Boulevard
II Galveston, Texas

Gott, Preston F. 49
Asst. Prof. Physics
Dept. of Physics, Texas Tech
I Lubbock, Texas

Grace, Sister Mary of 45
Teacher
Our Lady of the Lake College
San Antonio, 7, Texas

Graham, Mr. John F. 39
Head Dept. Mining & Metallurgy
College of Mines
I El Paso, Texas

Gravett, Howard G. 48
Asst. Prof. of Zoology
Box 145
II College Station, Texas

Gray, Dr. George R. 46
S Mgr. Gulf Coast Lab., Nat'l. Lead
6732 Sylvan Rd.
IV Houston, 3, Texas

*Gray, Mr. James A. 42F46
Animal Husbandman
Texas Extension Ser., Courthouse
V San Angelo, Texas

Gregoria, Sister Mary 38
Teacher
Our Lady of the Lake College
I San Antonio, 7, Texas

*Greulach, Dr. Victor A. 41F41
Dept. of Botany
Univ. of N. Carolina
Chapel Hill, N. C.

Grusendorf, A. A. 49
208 W. Wood St.
San Marcos, Texas

Gruy, H. J. 46
Pet. & Geo. Engineer
6026 Kenwood Ave.
I Dallas, Texas

Guido, Miss Virginia 49
Lab. Asst. Southwest Research Inst.
1510 W. Martin St.
II San Antonio, Texas

*Gunter, Gordon 36F40
Marine Biologist
Institute of Marine Sci., U of T
I Port Aransas, Texas

Gustafson, Mr. Arthur G. 44
Physics Teacher
710 Jefferson Ave.
I Seguin, Texas

Gutierrez, Dr. Gabriel V. 48
S Botanist
406 International House, Univ. of Calif.
Berkeley, 4, Calif.

*Hager, Dilsworth S. 44F48
S Oil Geologist & Oil Producer
932 Liberty Bank Bldg.
IV Dallas, Texas

Hagy, George W. 49
Student, Teacher
Biology Bldg. U. of T.
II Austin, Texas

Hakes, Mr. W. R. 47
Teacher, Brownsville Ind. Sch. Dist.
P. O. Box 1909
I Brownsville, Texas

Halbouty, Mr. Michel T. 46
S Consulting Geo. & Pet. Engineer
A 731 Shell Bldg.
IV Houston, Texas

Hall, Robert W. 49
Engineer
P. O. Box 1486
I Wichita Falls, Texas

Hamilton, Mr. Kenneth H.
Geologist, Union Oil of Calif.
720 Wilson Bldg.
IV Corpus Christi, Texas

Hamman, Mr. John Jr. 47
S Pres., Hamman Oil & Ref. Co.
A 2131 San Felipe Rd.
IV Houston, 19, Texas

*Hammond, Mr. T. M. 39F46
Prof. of Physics
F Schreiner Institute
I Kerrville, Texas

*Hampton, H. E. 40F46
Instructor in Soils
Agronomy Dept. A. & M.
II College Station, Texas

Hancock, Mr. J. M. 46
Pet. Geologist, Independent
A Box 68
IV Beeville, Texas

Harden, Lyn L. 46
Dist. Geologist
201 Staley Bldg.
Wichita Falls, Texas

Harding, John E. 49
Asst. Prof. Eco. & Mgt.
2610 21st St.
III Lubbock, Texas

*Hardt, Dr. Henry B. 44F47
Prof. of Chem. & Head Dept.
T. C. U.
I Ft. Worth, Texas

*Harris, Dr. Benjamin B. 29F30
Biologist, NTSTC Dean
T. C. Station, 415 Normal Ave.
V Denton, Texas

Harris, Dr. Joseph P. Jr. 46
Asst. Prof. Biology, S.M.U.
Biology Dept., S.M.U.
II Dallas, Texas

Harris, R. Merrill 49
S Consulting Geologist
P. O. Box No. 2385
I Jackson, Miss.

Hartwez, Dr. Norman 49
Curator, Div. of Reptiles and Amphi.
Univ. of Michigan
Ann Arbor, Michigan

Hatfield, Miss Sadie 48
Ext. Specialist, Landscape Gar.
Extension Bldg., A. & M.
II College Station, Texas

Hattox, Fay 49
Instructor, Foods & Nutrition
Texas Tech.
II Lubbock, Texas

Hazelwood, Dr. Emmett A. 48
Teacher, Texas Tech.
3218-20th St.
I Lubbock, Texas

*Heaps, Dr. C. W. 34F34
Prof. Physics
F 235 Portland, Rice Institute
I Houston, Texas

Hedeen, Mr. Robert A. 49
Grad. Student & Research Asst.
710 W. 22nd St.
II Austin, Texas

*Hedgpeth, Joel W. 45F46
Marine Biologist
Inst. of Marine Sci., U. of T.
II Port Aransas, Texas

Hedrick, Mr. O. F. 46
S Geologist, Pech Oil Co.
800 W. Michigan
IV Midland, Texas

*Hefley, Dr. Harold M. 40F47
Instructor in Zoology
Zoology Dept., Univ. of Ark.
II Fayetteville, Arkansas

Helwig, Mr. William F. 39
S Assoc. Prof. Electrical Eng.
U. of T., E. 147
I Austin, Texas

Herald, Frank A. (Mr.) 46
S Geo. & Research Science
1515 Preston Ave.
IV Austin, Texas

Henquet, Roger 49
Ex. Vice-Pres. & Gen. Mgr.
Schlumberger Well Sur. Corp.
P. O. Box 2175
IV Houston, 1, Texas

Herring, Mr. L. B. 46
Vice-Pres. & M'gr., Oil & Gas. Div.
A P. O. Box 2629
IV Houston, Texas

Herrmann, Jack A. 49
Grad. Student
1410 South Congress
II Austin, Texas

Herzog, Dr. Gerhard 49
S Director of Research, Texas Co.
P. O. Box 425
IV Bellaire, Texas

Hester, George C. 36
Prof. Govt.
S. U. Station
III Georgetown, Texas

*Heuse, Dr. E. O. F33
Head of Chem. Dept.
S.M.U., 3421 U. Blvd.
I Dallas, Texas

*Hewatt, Dr. Willis 33F40
Biology Prof.
TCU
II Ft. Worth, 9, Texas

Higdon, Mr. W. Dain 49
Asst. Prof. Biology
Ashby St.
II San Antonio, Texas

*Hildebrand, Dr. Earl Martin 48F49
Assoc. Prof. of Plant Pathology
F P. O. Box 4445
II College Station, Texas

Hiler, Mr. Irwin D. 46
Printer-Lithographer
Box 271
I Abilene, Texas

Hinckley, L. C. 46
Assoc. Prof. of Science
Sul Ross St. College
V Alpine, Texas

*Hodges, Mr. H. A. 31F37
Director Edinburg Jr. C.
P. O. Box 751
I Edinburg, Texas

Holland, Mary Loreen 46
S 2570 No. McGregor Dr.
IV Houston, Texas

Hollingsworth, Mr. A. K. 48
S Teacher, Chemistry
A Station A, Box 533
I Abilene, Texas

Hollingsworth, Mr. R. V. 46
Geologist, Paleontological Lab.
A P. O. Box 51
IV Midland, Texas

Holm, Dr. Hans Martin 49
Asst. Prof. Philosophy
A Box 22, McMurry College
III Abilene, Texas

Holzapfel, Dr. Ruth A. 44
Instructor, Head Div. Life Sciences
A Hardin College
II Wichita Falls, Texas

Hooks, Mrs. J. L. 37
1849 Calder Ave.
Beaumont, Texas

Hopkins, Sewell 49
T.C.U.
II Fort Worth, Texas

*Horvitz, Dr. Leo 44F48
Pet. Geochemist, Horvitz Research
A 3217 Milam
I Houston, 6, Texas

Hosington, Pauline 49
Asst. Prof. Biology
Box 674, Tarleton Station
II Stephenville, Texas

Hoxsey, H. M. 48
Naturapathic Physician
4507 Gaston Ave.
II Dallas, 4, Texas

*Hubbs, Dr. Carl L. 40F46
Prof. of Biology
F Box 109, Scripps Inst. Oceanogra
II LaJolla, Calif.

Hudnall, J. S. 46
Geologist
Box 988
IV Tyler, Texas

*Hudspeth, Mr. Jack C. 44F49
Pub. Div., Steck Co.
F Box 16
I Austin, Texas

*Huff, Dr. Z. T. 39F41
Dean of College
Howard Payne College.
III Brownwood, Texas

Huffman, Dr. Max N. 48
Prof. Biochemistry
A 2211 Oak Lawn Ave.
I Dallas, 4, Texas

Hughes, Mr. W. L. 38
Prof. Biology
A Box 296, North Texas Agric.
II Arlington, Texas

Hughes, Mr. William F. 38
Agricultural Economist
711 S. Coulter Dr.
V Bryan, Texas

Hull, Mr. Arthur M. 48
Dist. Geologist, U. S. Army Corp Eng.
604-C Santa Fe Bldg.
IV Galveston, Texas

Hunt, George R. 46
Asst. Prof. Science
Sul Ross St. Teachers Col.
I Alpine, Texas

Hurst, Mrs. Fannie Mae 49
Teacher, Baylor Univ.
II Axtell, Texas

Hurst, Mrs. Minor A. 49
5219 Young St.
V Houston, 19, Texas

Hyde, Mr. C. E. 46
Geologist & Oil Producer
1715 W. T. Waggoner Bldg.
IV Ft. Worth, 2, Texas

*Irons, Dr. J. V. 38F46
Asst. Dir. of Laboratories
1608 E. Ave.
II Austin, Texas

Ivy, Edward E. 47
Box 834
College Station, Texas

*Ivy, John 39F
1124 Neils Esperson Bldg.
Houston, Texas

Jackson, Dr. Doyle D. 49
Prof. Edu. Psychology
Box 61, Tech Station
III Lubbock, Texas

Jackson, Mr. R. E. 37
Pres., East Texas Big Thicket Assn.
A P. O. Box 64
III Silsbee, Texas

*Jakkula, Dr. A. A. 45F46
Exec. Director, Tex. A & M Research
A Research Foundation, F. E. Box 44
I College Station, Texas

*James, Mr. William Alonzo 29F32
S Ball High Sch. Prin., Emeritus
A 2327 Ave. M.
I Galveston, Texas

Jameson, David L. 48
Student, Teaching Fellow
c/o Zoology Dept., U. of T.
II Austin, Texas

Japhet, W. E. 49
S Pres., Southern Blue Print
Drawer 2643
I Houston, 1, Texas

Johnson, Mrs. Bessie K. 35
611 N. W. Levee St.
III Brownsville, Texas

Johnson, J. C. 46
Soil Conservation
2110 Pearl
II Austin, 21, Texas

Johnston, Mr. George L. 42
Publisher, Transportation Press
P. O. Box 381
II Dallas, Texas

Johnston, Dr. Ola 44
Prof. Biology, NTSC
A 1801 W. Mulberry
II Denton, Texas

Jolley, Durward N. 46
Consulting Geologist
230 Evans Ave.
IV San Antonio, 9, Texas

*Jones, Dr. Clifford B. 39F
Pres. of Texas Tech., Emeritus
3501 19th St.
Lubbock, Texas

Jones, Mr. Herman T. 48
Instructor in Biology
Prairie View A. & M.
II Prairie View, Texas

*Jones, Dr. Luther G. 44F49
Prof. Agronomy
F Box 1588
II College Station, Texas

Jones, Mr. Marvin R. 49
Engineer ,Oil Center Tool Co.
P. O. Box 3091
I Houston, Texas

*Jones, W. Goodrich 33F35
Box 1585, 326 N. 14th St.
Waco, Texas

Jones, Dr. W. Norton 49
Prof. of Chem. & Head Dept.
758 Amarillo St.
I Abilene, Texas

Jones, Walter B. 49
S State Geologist
Tuscaloosa, Alabama

Judson, Sidney A. 34
Consulting Oil Geologist
3783 Carlon St.
IV Houston, 5, Texas

Keating, Mr. Thomas W. 46
S Drilling Research Engineer
Box 3022
IV Houston, 1, Texas

Keith, John W. 46
S Chemist
2225 Pecos
II Beaumont, Texas

Keith, Lillian 37
Box 1017
Crystal City, Texas

Kelsay, Miss June 47
Instructor
Box 5647, T. C. Station
II Denton, Texas

*Kemp, Mrs. Augusta Hasslock 30F38
F Box 626
IV Seymour, Texas

*Kemp, Hardy A., M. D. 35F38
Director of Grad. Studies
F Baylor Univ. Med. College
II Houston, Texas

Kenyan, Mrs. Frances M. G. 49
Asst. Prof. Bio. Science
UCC
II Corpus, Christi, Texas

*Kerbow, Dr. A. L. 44F46
Head, College of Ed., U. of H.
A 3220 Rice Blvd.
III Houston, Texas

Kern, Mr. Jack C., Jr. 46
Geophysical Supr. Standard Oil
Co. of Texas
3815 Greenbrier Dr.
IV Dallas, Texas

Key, Dr. Sam N. Jr. 49
Eye Surgeon
505 Capital Nat'l. Bank Bldg.
Austin, Texas

Key, Dr. Sam N. Sr.
Eye Surgeon
505 Capital Nat'l. Bank Bldg.
Austin, Texas

Kiester, Mr. Robert S. 49
Instructor
1908 Carroll Dr., Apt. 1
IV Houston, 4, Texas

*Killough, D. T. (Mr.) 34F34
A Dept. of Agronomy, Box 32, A.&M.
II College Station, Texas

Kirby, Grady 47
1521 Esperson Bldg.
Houston, Texas

Kinchen, Oscar A. 49
History Prof.
Tech Station
III Lubbock, Texas

King, R. W. 49
Head of Biology Dept., S. A. Pub. Sch.
71 East 19th St.
II San Angelo, Texas

Kirkland, Mrs. Forrest 46
911 S. Van Buren
Dallas, 8, Texas

*Kirn, Albert J. 30F38
S Drawer 7
IV Somerset, Texas

Kister, Tom L. 49
Asst. Lab. Instructor
U. of H.
Houston, Texas

*Klaus, Hellmut 46F48
S Box 1617
IV Lubbock, Texas

Klett, Miss Mamie 48
Biology Dept., Baylor
A 2417 Columbus St.
II Waco, Texas

Knapp, Mr. Frank T. 48
Asst. Prof. of Fisheries, A. & M.
Box 254 F. E.
V College Station, Texas

S Knox, T. K. 46
IV Maypearl, Texas

Koch, Miss Lina Clara 49
History Teacher
III 423 S. Alamo St.,
San Antonio, Texas

Koenig, J. B. 47
206 East Wall
Midland, Texas

*Kornfeld, Joseph Alton 46F47
Engineer, Reservoir, Sohio Pet. Co.
2300 First Nat'l. Bk. Bldg.
I Oklahoma City, Okla.

Kraushaar, William F. 41
President
Texas Lutheran College
III Seguin, Texas

Krieger, Mr. Alex Dony 44
Archaeologist
A Anthropology Dept., U. of T.
III Austin, Texas

*Kuehne, Dr. J. M. 29F29
Prof. of Physics
Univ. Station, U. of T.
I Austin, Texas

LaBrier, Dr. George W. 49
Owner & Instructor, C. C. Bus. Col.
306 Lawrence St.
III Corpus Christi, Texas

*LaMotte, Dr. Charles 30F36
Professor of Biology
A Box 4783, Biology Dept., A. & M.
II College Station, Texas

Langhammer, E. G. 48
Texas Filter Co., Inc.
300 Blum, P. O. Box 367
San Antonio, 6, Texas

Larson, Mr. Lennart V. 43
Prof. of Law
S. M. U., Law School
I Dallas, Texas

LaRue, J. E. 47
P. O. Box 2180
Humble Bldg.
Houston, Texas

LaRue, Wilton W. 47
Plymouth Oil Co.
Sinton, Texas

*Lay, Mr. Daniel W. 44F47
Wildlife Biologist, G. F. & O. C.
Box 609
V Silsbee, Texas

*Leake, Dr. Chauncey D. 42F46
S Exec. Vice-President
F 1000 Strand
III Galveston, Texas

Leasure, John Hicks 44
Florist, Cactus Acres
4431 Montana Ave.
III El Paso, Texas

*Lee, Addison 39F46
Dept. Botany & Bacteriology
1703 W. 44th St.
Austin, Texas

Lee, Mr. Sidney 46
Director Dallas Lab.
2500 South Ervay
I Dallas, 1, Texas

Lee, Sister Stanilaus 49
High Sch. Science Teacher
4701 Broadway
I San Antonio, Texas

Leidigh, Arthur H. 49
Agronomy Prof.
Texas Tech
Lubbock, Texas

Leifeste, Mr. Sam 49
Asst. Prof. Marketing
Texas Tech., Marketing & Sec. Ad.
III Lubbock, Texas

Leonard, Archie L. 49
Asst. Prof.
Ag. Eco., Texas Tech
II Lubbock, Texas

*Leonardon, Mr. E. G. 43F46
Director Schlumberger Well Sur. Corp.
P. O. Box 2175, 2720 Leeland Ave.
I Houston, Texas

*LeVesconte, Dr. Amy 37F
Prof. of Chemistry
F Mary Hardin Baylor Univ.
I Belton, Texas

Levett, Frank W. 49
Inst. Engr. Drawing & Sur.
1801 Univ. Blvd.
I Abilene, Texas

Lewis, Miss Genelia E. 39
Chem. Teacher, TSCW
627 Oakland
Denton, Texas

Lewis, Hosea H. 47
1241 Washington Blvd.
Abilene, Texas

*Lewis, Mr. James O. 46F48
Pet. Consultant
1552 Mellie Esperson Bldg.
IV Houston, Texas

Lewis, Dr. S. R. 49
Surgical Resident
John Sealy Hospital, Dept. of Sur.
II Galveston, Texas

*Lindsay, J. D. 45F47
Professor
Dept. of Chem. Eng.
College Station, Texas

Lindsay, John W. 49
Instructor
3313 30th St.
I Lubbock, Texas

Little, Dr. Robert N. 47
Prof. Physics
A Physics Dept., P. B. 304, U. of T.
I Austin, Texas

*Little, V. A.
Prof. of Entomology 44F47
A. & M. College
II College Station, Texas

Lockwood, Mr. Mason G. 49
S Engineering, Consulting
904 Union Nat'l. Bank Bldg.
I Houston, Texas

*Loefer, Dr. John B. 48
Chief Biologist, Found. App. Res.
Foundation of Applied Research,
P. O. Box 2296
II San Antonio, Texas

Lohse, Edgar A. 48
Instructor, U. of H.
3000 Griggs Rd.
IV Houston, Texas

Lokey, Dr. Clarence Walters 42
Supt. Dept. of Spanish Speaking
& Indian Work in S'West
230 E. Travis St.
III San Antonio, 5, Texas

Lonsdale, John T. 48
Geologist
Bureau of Eco. Geology, U. of T.
V Austin, Texas

Loose, William E. 49
S Atty. at Law, Texas Co.
2132 Rice Blvd.
V Houston, Texas

Lott, Miss Mary Harriet 48
Research Chemist, S. W. Med. Col.
A 2211 Oak Lawn
I Dallas, 4, Texas

Louden, Mr. H. W. 46
Mgr. Field Ser. Eng. Dept.
700 City Nat'l. Bldg.
IV Houston, 2, Texas

Love, Perry R. 47
Box 450
Yoakum, Texas

Lowman, Sheppard 47
Box 2099
Houston, Texas

Lozo, Dr. Frank E. Jr. 43
Geologist, Shell Oil
3737 Bellaire Blvd.
IV Houston, 5, Texas

*Ludeman, Miss Helen A. 39F46
S Prof. of Chemistry
A Box 2475, T. S. C. W.
I Denton, Teas

*Luska, Dr. Frank E. 45F48
Acting Head Dept. Soc.
905 Walnut St.
III Georgetown, Texas

*Lynch, S. A. 44F46
S Head Dept. Geology
Dept. of Geology, A. & M.
IV College Station, Texas

Maley, W. A. 47
2235 Maroneal
Houston, 5, Texas

Malmberg, Myrtle E. 49
Registered Nurse
Box 654, A. & I. College
II Kingsville, Texas

Mangrum, James F. 46
Instructor of Zoology
P. O. Box 1131
II College Station, Texas

Manuel, Dr. Herschel T. 47
Prof. Ed. Psychology
Univ. of Texas
III Austin, Texas

Marlow, Dr. H. W. 48
Associate Prof. Biochem.
2211 Oaklawn
I Dallas, 4, Texas

Marr, Mr. John C. 49
Marine Fisheries Biologist
A 450-B Jordon Hall
II Stanford, Calif.

Marshall, Dr. Madison L. 47
Prof. of Chemistry
A TSCW 3654
I Denton, Texas

*Marsteller, Dr. R. P. 35F40
Vet. Med. & Surgery
Veterinary Hospital 103
II College Station, Texas

Martin, Dail 42
Dept. of Entomology
Dept. of Entomology, A. & M.
College Station, Texas

*Mason, Mr. Shirley L. 46F48
S Geologist
1801 Bolsover Rd.
IV Houston, Texas

Maspero, Miss Barbara 49
Allergy & Mycology
311 Glenwood Ct.
II San Antonio, 10, Texas

*Mathews, A. A. L. 43F49
S 3801 St. Bernard St.
IV Houston, 4, Texas

Matthews, Mr. R. D. 38
S Salesman, Central Scientific Co.
4221 Amherst
I Dallas, 5, Texas

Maxwell, Mr. Ross A. 46
Supt., Big Bend Nat'l. Park
Big Bend Nat'l Park
IV Marathon, Texas

May, Miss Lida B. 44
Instructor, Texas Tech.
Texas Tech College
I Lubbock, Texas

Mayfield, William I. 46
S 1800 Grace
IV Wichita Falls, Texas

Mayhall, Mrs. Mildred P. 34
Instructor in Anthropology
1906 Raleigh
II Austin, Texas

Mays, Fleming L. 49
S Executive Secretary
1810 Pet. Bldg.
V Houston, Texas

Mebane, Robert Duff 47
914 Milam Bldg.
San Antonio, Texas

Medlen, Mr. A. B. 47
Biology Dept., A. & M.
Biology Dept. A. & M.
II College Station, Texas

Melton, R. B. 49
Economics Dept., N. T. S. T. C.
Box 6132, T. C. Station
III Denton, Texas

Menzel, Mr. R. Winston 49
Biology Research Lab.
A Texas A. & M. Research Foundation
II College Station, Texas

Merkle, Mrs. John 49
Housewife
Biology Dept., A. & M.
II College Station, Texas

Merkle, Dr. John 49
Asst. Prof. Biology
A Biology Dept., A. & M.
II College Station, Texas

Merkt, Ernest E. 46
P. O. Drawer 1290
IV Ft. Worth, 1, Texas

*Merrymon, William W. (Dr.) 48F49
Assoc. Prof. Physics
F 2213-24th St.
I Lubbock, Texas

Michie, Mrs. J. N. 45
Texas Tech College
I Lubbock, Texas

*Michie, James Newton 34F31
Prof. & Head Math. Dept.
Dept. of Math, Texas Tech.
Box 91
I Lubbock, Texas

Micks, Don W. 49
Asst. Prof. Prev. Med.
Dept. of Prev. Med. & Pub. Hlth.
II Galveston, Texas

Mikus, Dr. F. F. 49
Assoc. Prof. Chem.
Chem. Dept. Texas A. & I.
I Kingsville, Texas

Miller, Mr. Buford 47
Geologist, Melben Oil Co.
A 2305 Esperson Bldg.
IV Houston, 2, Texas

Miller, C. C. 47
3448 Aransas St.
Corpus Christi, Texas

Miller, Clay E., Jr. 49
Student, U. of T.
II Ft. Davis, Texas

Miller, Dr. E. L. 49
Head & Prof. Biology
A S. F. A. S. T. C.
II Nacogdoches, Texas

Miller, L. L. 38
Dept. of Physics
NTSTC
Denton, Texas

Milliff, Dr. J. H. 45
Prof. & Head Dept. Veterinary
Anatomy
Box 212 F. E.
II College Station, Texas

*Milligan, Dr. W. O. 38F41
Assoc. Prof. Chemistry
A P. O. Box 1892
I Houston, Texas

Milstead, Mr. W. W. 49
Grad. Student, U. of T.
2814 N. Guadalupe
II Austin, Texas

*Miner, Mrs. Edna W. 37F48
Biology Teacher
2206 Brun St.
II Houston, Texas

Mitchell, Mr. Robert B. 47
Consulting Geologist & Eng.
2218 City Nat'l. Bk. Bldg.
IV Houston, Texas

*Mogford, Joseph S. 42F47
Dept. of Agronomy, A. & M.
College Station, Texas

*Monning, Mr. Oscar E. 39F49
S Vice-Pres., Monning Dry Goods
F 1010 Morningside Dr.
I Ft. Worth, 3, Texas

Montgomery, Mr. J. C. 47
Chief Geo. & Pet. Eng., Indiola
A 3204 Gulf Bldg.
IV Houston, Texas

*Moody, Mr. Clarence L. 49F49
S Div. Geologist, Ohio Oil Co.
F Ohio Oil Co.
IV Shreveport, Louisiana

*Moore, Miss Elizabeth J. 39F46
Research Assoc.
A Box 1683, Univ. Station
II Austin, 12, Texas

Moore, Mr. Fred H. 49
Geologist, Magnolia Pet. Co.
3023 Purdue
IV Dallas, 5, Texas

Moore, Joe L. 47
Drawer 1391, Honolulu Oil Corp.
Midland, Texas

*Moore, Dr. Robert M. 46F48
S Prof. Surgery & Chmn. Dept. Sur.
Med. Sch. Univ. of Texas
Galveston, Texas

Morales, Apolonio 49
Technician, Found. App. Research
1035 San Francisco St.
I San Antonio, Texas

*Morgan, Dr. Joseph 46F46
Prof. Physics
A Phy. Dept., T. C. U.
I Ft. Worth, Texas

*Morris, Dr. Kelso B. 45F46
S Assoc. Prof. Chemistry
A Dept. of Chem. Howard Univ.
I Washington, 2, D. C.

Morris, Louis H. 47
Consulting Geologist
McBurnett Bldg.
San Angelo, Texas

*Morrow, Miss Marie B. 30F
Asst. Prof. Dept. Bot. & Bact.
F 1305 W. 22nd St.
II Austin, Texas

*Morse, Roy R. 46
S Shell Oil Co.
Box 2099
IV Houston, Texas

Moser, Dr. Stella 49
Physician
209½ San Antonio St.
II New Braunfels, Texas

*Mortensen, Mr. E. 30F33
Horticulturist
F Ag. Exp. Sta. Sub. Sta. 19
II Winter-Haven, Texas

Morton, Dr. Ohland 48
Principal, Edinburg High Sch.
A Edinburg High School
III Edinburg, Texas

Moss, Mr. F. P. 44
Director of Guidance
Schreiner Institute
II Kerrville, Texas

*Mount, Mr. A. W. 45F46
S Div. Main. Super., S.W.Bell Tele.
A 4326 Birchman St.
I Ft. Worth, 7, Texas

Mueller, Margaret 49
Housewife
438 Haggin St.
II San Antonio, Texas

*Mulaik, Mr. Stanley B. 33F40
Biology Instructor
Univ. of Utah
II Salt Lake City, 1, Utah

*Mullings, Marcus Evans 46F46
Prof. of Math.
Station A
I Abilene, Texas

Murphy, Clifford 49
Asst. Prof. Biology
Bio. Dept., T. C. U.
II Ft. Worth, Texas

Murray, William J. Jr. 49
Chmn., R. R. Commission
A Tribune Bldg.
V Austin, Texas

Myers, Ernest L. 47
S Consulting Engineer
2204 Tower Pet. Bldg.
Dallas, 1, Texas

Myers, Mr. J. Sutton 44
S General Contractor
Rt. 2, Box 388
IV Brownsville, Texas

McAlister, James E. 48
Teacher
Boles Home
Quinlan, Texas

McAnis, Ava J. 46F49
Assoc. Prof. of Chemistry
202 East Park Ave.
I San Antonio, Texas

*McBryde, Dr. J. B. 44F46
Biology Teacher
615 W. Sycamore St.
II Denton, Texas

McCall, Miss Carol 47
Biology Instructor
A Box 140, Biology Dept., Baylor U.
II Waco, Texas

*McCart, William Larrey (Mr.) 37F47
Entomologist, Teacher
A 1309 St. Louis Ave.
II Ft. Worth, 2, Texas

McClintock, Haskell 49
Asst. Prof. of Biology
Texas Wesleyan College
II Ft. Worth, Texas

*McCollum, Burton 34F34
Geophysicist
2949 Chevy Chase Dr.
I Houston, 19, Texas

*McConnell, Dr. W. J. 36F40
President, NTSTC
F T. C. Station
Denton, Texas

McCoy, Mr. George Y. 47
Pet. Consultant
A Empire Bank Bldg.
IV Dallas, 1, Texas

McCully, Mr. Wayne G. 48
Asst. Field Leader, Agri. Expt. S.
Box 5325
V College Station, Texas

*McDonald, Dr. Frank 46F47
Prof. Physics & Chmn. Dept.
F Physics Dept., S. M. U.
I Dallas, Texas

McDonald, Maude 48
Asst. Mgr. Bureau
Texas Emp. Comm., Box 432
Pt. Arthur, Texas

*McGavock, William C. (Dr.) 40F41
Chem. Prof.
1702 Waverly Ave.
I San Antonio, Texas

*McGregor, Stuart 38F40
S Editorial Writer, Dallas News
4557 Belclaire Ave.
Dallas, Texas

McIlhenny, E. A. 38
Pres. McIlhenny Co.
II Avery Island, La.

*McKay, Jack M. M. D. 45F46
Physician & Surgeon
110 E. Pecon St.
II Gainesville, Texas

McKinney, Miss Cornelia 35
1527 Ave. J.
Huntsville, Texas

McLeod, Claude A. 49
Biology Teacher
Sam Houston State College
II Huntsville, Texas

McMillan, Mr. E. A. 49
Teacher Alpine Pub. Sch.
Box 502
III Alpine, Texas

McNeese, James 49
Public School Teacher
Box 14
I Port Aransas, Texas

Neeley, Coleman L. 49
Electrical Engineer
206 Panama
San Antonio, Texas

Nelson, George F. 48
1501 Lindberg, Sta. D.
Baytown, Texas

Nelson, Dr. L. A. 45
Physician
4105 Live Oak
I Dallas, Texas

Nelson, Sherman 49
S Owner, Nelson Tie Co.
P. O. Box 228
IV Seguin, Texas

Neuman, Leonard J. 48
Consulting Engineer
943 M. Esperson Bldg.
IV Houston, 2, Texas

*Neville, Wm., Jr. 39F
Assoc. Prof. Pharmacy
1710 W. 6th St.
I Austin, Texas

Niermon, Dr. John L. 35
Director Grad. Studies
Texas A. & I.
I Kingsville, Texas

Noake, Mr. Joe A. 49
Biological Research & Breeding Earthworms
1842 W. Mistletoe Ave.
II San Antonio, Texas

Normand, Emma 39
Teacher, SHSTC
II Huntsville, Texas

O'Banion, E. E. 48
Chmn. Chem. Dept.
Prairie View A. & M.
I Prairie View, Texas

*O'Byrne, Sister Michael Edward 32F35
Chmn. Physical Sciences
A Incarnate Word College
I San Antonio, Texas

Ofield, William J. 49
Instructor
216 Hunt St.
IV Houston, Texas

Olcott, Perry 47
Box 2180
Houston, Texas

Oliphant, Elizabeth Ann 45
Asst. Prof. Math
Texas A. & I.
I Kingsville, Texas

*Oliver, Dr. Clarence P. 48
Zoology Prof.
F Dept. of Zoology, U. of T.
V Austin, Texas

O'Neil, Mrs. Norah S. 34
Asst. Biology Prof., ETSTC
A 1311 Bonham St.
II Commerce, Texas

*Oppe, Miss Greta 29F31
S Head Science Dept.
F 1609 Ave. K.
I Galveston, Texas

Orman, Mr. Freeman L. Jr. 46
Geologist, Republic Nat'l. Gas Co.
A Box 1755
IV Dallas, 1, Texas

Orr, Mary Faith 49
Research Assistant
U. of T. Med. Branch
II Galveston, Texas

*Osterhoudt, Walter 46F48
S P. O. Drawer 2100
IV Houston, Texas

Overall, Dr. John Wayne 45
Teacher of Physics, A. & M.
A 611 South Baker Ave.
I Bryan, Texas

*Owen, Ed Wesley 30F30
Geologist, L. W. Wentz (Oil Div.)
532 Milam Bldg.
IV San Antonio, 5, Texas

Owen, Dr. May 47
Pathologist, Terrell's Lab.
Box 1719
I Fort Worth, Texas

*Paine, L. S. (Mr.) 39F46
S Assoc. Prof. Agric. Eco.
Box 4431
II College Station, Texas

Parencia, Charles R., Jr. 47
Box 1218
Waco, Texas

Parker, Dr. Grady P. 47
Education Dept. A. & M.
Box 226
III College Station, Texas

Parker, Travis J. 47
Assoc. Prof. Geology
Geology Dept., A. & M.
IV College Station, Texas

Parker, W. G. 45
Box 2100
Houston, Texas

Parks, Mabel 48
S Teacher, TSCW
521 Texas St.
Denton, Texas

Parnell, E. D. 49
Teacher, A. & M.
P. O. Box 366
III College Station, Texas

Parr, Mildred 49
Chemistry Teacher
1333 Ocean Dr.
I Corpus Christi, Texas

Parsons, Dr. L. D. 44
Prof. Chem. & Head Dept.
1612 Cooper St.
I Commerce, Texas

Patrick, W. W. 47
3764 Garnet St.
Houston, Texas

Paxson, Mr. Roland B. 47
S Consulting Geologist
4202 St. Emanuel St., Apt. 4
IV Houston, 4, Texas

Peacock, Mr. Dan 49
Instructor Chemistry
Box 701, Tarleton Station
I Stephenville, Texas

Pence, Prof. Forrest K. 47
Dept. of Ceramic Engineering
Univ. of Texas
I Austin, Texas

Pennington, Dr. J. V. 48
Assoc. Dir. S. W. Research Inst.
1320 City Nat'l. Bank Bldg.
I Houston, 2, Texas

Pequeno, Dr. Eduardo Aguirro 47
Institute de Investigaciones Cientificas
de la Univ. de N. Leon
Apdo. 897
Monterrey, Nuevo Leon, Mexico

Perini, Mr. V. C. Jr. 46
Geologist & Oil Producer
Box 840
IV Abilene, Texas

Person, Mr. Hubert L. 46
Forester, So. Forest Exp. Sta.
Box 57, North St. Station
II Nacogdoches, Texas

Peterson, Mr. Randolph L. 47
Div. of Mammals, Royal Ont. Mus.
A 100 Queen's Park
II Toronto, Ontario, Canada

*Petty, Mr. O. S. 40F47
S Pres., Petty Geophysical Eng. Co.
P. O. Box 2061
V San Antonio, Texas

Petty, T. F. 47
S Humble Oil & Refining Co.
Box 840
Wichita Falls, Texas

Petty, Van A. Jr. 45
S Geologist
P. O. Box 2061
IV San Antonio, Texas

Phelps, Dr. Austin 48
Prof. Zoology, U. of T.
A Box 1972, Univ. Station
II Austin, Texas

Philipp, E. R. 44
Atlantic Ref. Co.
7307 Tokalon Dr.
Dallas, Texas

Phillips, Mr. Homer Wayne 48
Student, U. of T.
2208 Wroxton Rd.
II Houston, 5, Texas

*Pilcher, Dr. John F. 40F46
S Physician, Terrell-Pilcher Lab.
A 320 Med.-Professional Bldg.
II Corpus Christi, Texas

Pittman, Dorothy G. 49
Biology Prof.
Box 96, Tarleton Station
II Stephenville, Texas

Platt, Volney M. 49
Lab. Director
1710 W. Summit Ave.
III San Antonio, Texas

*Pomerat, Dr. C. M. 44F46
S Prof. of Anatomy
Med. Branch U. of T.
II Galveston, Texas

*Porter, Eugene L. 45F46
Prof. of Physiology
Univ. of Texas Med. College
II Galveston, Texas

Porter, Dr. Lon V. 48
Asst. Prof. Fixed Multiple Res.
1018 Blodgett
II Houston, 4, Texas

Potter, Mr. Floyd E., Jr. 49
Student, Univ. of Texas
3400 Cedar St.
II Austin, 21, Texas

*Potter, Dr. Geo. Edwin 30F33
Prof. Zoology & Prev. Med. Adv.
Box F. E., A. & M.
II College Station, Texas

Potts, C. S. 46
Dean Law School
III S. M. U., Dallas, Texas

Powell, Ernest H., Jr. 48
Field Asst. Biologist
Inst. of Marine Sci. Lab.
II Port Aransas, Texas

Powell, Ralph S. 47
4444 Fairway Ave.
Dallas, Texas

Powell, Mr. W. J. 47
Consulting Engineer
501 Thomas Bldg.
I Dallas, 1, Texas

*Power, Harry H. 43F46
Prof. Pet. Engineering
2600 Wooldridge Dr.
IV Austin, Texas

Prescott, T. B. 49
Teacher, Minister, S. H. S. T. C.
P. O. Box 934
III Huntsville, Texas

*Prince, Dr. Homer E. 39F46
Allergist
A 808 Caroline
II Houston, Texas

*Prouse, Dr. Ervin J. 44F46
Instructor, Univ. of T.
F 3215 Liberty St.
I Austin, Texas

Puzin, L. A. 47
S 1515 Apco Tower
Oklahoma City, Okla.

*Quisenberry, Dr. John H. 37F
F Poultry Dept., A. & M. F. E.
II College Station, Texas

Rabb, Edward Layne 49
Biology Instructor, Allen Mil. Acad.
1312 Ursuline Ave.
II Bryan, Texas

*Rabideau, Glenn Sylvester (Dr.) F46
F Dept. Bot. & Bact., U. of T.
II Austin, Texas

Ramsey, Dr. Glenn V. 49
Prof. of Psychology, U. of T.
1308 Bentwood Rd.
III Austin, Texas

Ramsey, Louis Weete 48
S Box 441, T.C.U.
Ft. Worth, 9, Texas

Randolph, Neal M. 49
Acting Prof.
Box 425, Tarleton Station
II Stephenville, Texas

*Ransone, Mr. W. R. 43F48
S Managing Partner, Geochem. Sur.
A 3806 Cedar Springs Ave.
IV Dallas, Texas

Rasmussen, Mr. William C. 49
Geologist, Speed Oil Co.
Box 4863
IV College Station, Texas

*Ray, Dr. Cyrus N. 46F46
Texas Archeological & Paleon. Soc.
Box 62
II Abilene, Texas

Reagan, Mr. P. H. 46
A Mining Engineer
IV Hye, Texas

Redfield, Mr. Robert C. 46
Gen. Mgr., Stone Products Inc.
A 2101 Schulle,
IV Austin, Texas

*Reid, Mrs. Bruce 37F
Box 218
Kountze, Texas

Reid, Mr. Duncan H. 44
Prof. Poultry, A. & M.
P. O. Box 355, Poultry Hus. Dept.
II College Station, Texas

Richards, Dr. Arthur 47
Teacher
Dept. Geology, SMU
IV Dallas, Texas

Richardson, Dr. Luther R. 48
Assoc. Prof. Biochem. & Nutrition
Box 102
II College Station, Texas

Rix, Mr. R. A. 44
Head Dept. Agriculture
1611 Stonewall St.
II Commerce, Texas

Robinson, Ernest Guy 44
Mgr. Exploration, Shell Oil Co.
P. O. Box 100
IV Calgary, Alberta, Canada

Roddy, Roy 49
Agriculture Editor
Dallas Morning News
II Dallas, Texas

Roden, Harry 47
S The Texas Co., Box 457
Pt. Neches, Texas

Rogers, Claude Marvin 49
Instructor, Univ. of Texas
Botanical Lab. U. of T.
II Austin, Texas

*Rogers, Dr. Fred T., Jr. 42F46
Science Dept., Michelson Lab.
China Lake, Calif.

*Rogers, Dr. Marguerite 42F46
Science Dept., Michelson Lab.
China Lake, Calif.

*Rosaire, Dr. E. E. 46F48
S Consulting Geophysicist, Subterrex
F Route 7, Box 412-D
I Dallas, Texas

Rose, H. W. 47
S c/o Sun Oil Co., P. O. Box 2880
Dallas, 1, Texas

*Rosenblad, Dr. L. E. 40F47
M. D., Schmidt-Rosenblad Clinic
Box 749
V Velasco, Texas

Roston, Mr. J. Paul 47
Dept. of Pet. Eng., U. of T.
A 407 W. 18th St., Apt. 114
IV Austin, Texas

Roth, Dr. Joseph M. 41
Head Dept. of Phil. & Psy.
College of Mines
III El Paso, Texas

Rothschild, Miss Babette 49
Instructor Biology, U. of H.
5006 Calhoun Dr., Apt. 24
II Houston, Texas

*Rouse, Dr. John T. 46F49
Regional Geologist, Magnolia Pet.
F P. O. Box 900
IV Dallas, Texas

Rowden, Dale H.
S 2801 Transit Tower
IV San Antonio, 5, Texas

Rowell, Chester M. (Mr.) 46
Botany Instructor
A Box 2088, A. & M.
II College Station, Texas

Rush, R. R. 46
Box 686
I San Marcos, Texas

Russell, Daniel (Mr.) 46
Prof. of Rural Sociology
A Box 255, F. E.
III College Station, Texas

Russell, J. J. Jr. 46
S Pet. Geologist
P. O. Box 2406
IV Wichita Falls, Texas

Russell, P. G. 46
Geologist
P. O. Box 2837
III Dallas, Texas

*Rutherford, Mr. Charles R. 39F48
S Research Physicist, Def. Res. Lab.
I Mt. Vernon, Texas

Rypma, Mr. Richard B. 49
Teacher
A Box 13, A. & M. Annex
II College Station, Texas

Samuell, Mr. John Howard 46
S Pet. Engineer
First Nat'l. Bk.
IV Dallas, Texas

*Sanden, Rev. O. E. 39F46
Minister & Dean N'Western Sch.
50 Willow St.
I Minneapolis, 3, Minnesota

Sanders, Mrs. Ottys 30
Asst. Prof., Med. Art, S.W. Med. Col.
P. O. Box 4084
II Dallas, Texas

*Sanders, Mr. Ottys 39F39
M'gr. Southwestern Bio. Supply Co.
A Box 4084
II Dallas, 8, Texas

Sanders, Virginia D. 49
Med. Technologist
114 Davis Court
II San Antonio, 2, Texas

*Sauer, Mrs. Mary Elmore 44F46
Asst. Prof. Anatomy
F 1115 Post Office St.
II Galveston, Texas

Schaeffer, Hugh C. (Mr.) 46
Schaeffer Geophysical Co.
A P. O. Box 2036
IV Shawnee, Okla.

*Schlesselman, Dr. G. W. 43F46
Box 2, F. E., Geography Dept.
IV College Station, Texas

*Schmidt, Dr. C. C. 40F48
S Head Physics Dept.
F Physics Dept. Texas Tech.
I Lubbock, Texas

*Schoffelmayer, Mr. Victor H. 40F44
S Retired Editor, Dallas Morning News.
A 4440 Beverly Dr.
II Dallas, 5, Texas

Scholl, L. A. Jr. 46
Mgr. Geophysical Div., Texas Co.
1812 Banks
IV Houston, 6, Texas

*Schrank, Dr. A. R. 44F46
Biological Sciences Prof.
A Dept. of Zoology & Physiology, UofT.
Austin, Texas

Schreiner, Charles III 49
Rancher
Y. O. Ranch
II Mt. Home, Texas

*Schuchardt, Dr. V. T. 39F45
S Teacher, U. of T.
F Bacteriology Dept., U. of T.
II Austin, Texas

*Schulze, Mr. B. E. 35F46
Teacher Physics, Del Mar College
A 2919 Dempsey St.
I Corpus Christi, Texas

Schumacher, J. P. 47
S 1348 Esperson Bldg.
Houston, Texas

Schwartz, Miss Guydell L. 49
Microbiologist, Navajo Med. Cen.
II Ft. Defiance, Arizona

Schwennesen, A. T. 49
S Geologist
2702 N. Esperson Bldg.
IV Houston, 2, Texas

Scobey, Ellis H. 46
807 Cuthbert
IV Midland, Texas

*Scoular, Dr. Florence I. 39F39
S Prof. & Dir. Home Eco.
A Box 5217, T. C. Station
II Denton, Texas

Searle, E. H. 44
Oil tester-inspector
3033 Alamo Ave.
Pt. Arthur, Texas

Selig, A. L. 46
3101 Gulf Bldg.
IV Houston, 2, Texas

Sergeant, Tom P. 49
Asst. Prof.
Trinity Univ.
San Antonio, Texas

Shearer, Dr. A. R. 39
S Country Doctor
Box 428
II Mont Belvieu, Texas

Sheets, Martin M.
Chief Geologist
A 1450 M. Esperson Bldg.
IV Houston, Texas

Sherar, Stuart 47
1307 Esperson Bldg.
Houston, Texas

Sherer, Charles R. 48
Prof. of Math
Math Dept. T. C. U.
I Fort Worth, Texas

Shigley, C. M. 49
Asst. Gen Mgr.
Dow Chem. Co.
I Freeport, Texas

*Shinners, Dr. Lloyd H. 45F46
Asst. Prof. Biology
A S.M.U.
II Dallas, 5, Texas

Showalter, W. P. 49
Chem. Prof.
1060 W. Sloan
Stephenville, Texas

Siemer, Bro. William J. 49
Prof. of Geology
St. Mary's Univ.
San Antonio, Texas

Silverberg, Edwin 49
Teacher, General Science
1035 Prince St.
II Beaumont, Texas

*Silveus, Mr. W. A. 33F47
Lawyer & Author
A 832 Cambridge Oval
II San Antonio, 9, Texas

*Silvey, Dr. J. K. G. 44F
Biology Prof., Chmn. Sci. Div.
A T. C. Station
II Denton, Texas

*Silvey, Dr. O. W. 30F30
Dept of Physics, A. & M.
I College Station, Texas

Simons, Mr. Verne F. 49
S Certified Public Acct.
A Box 1892
III Houston, Texas

*Singleton, Dr. Gordon G. 40F47
Pres. of Mary Hardin Baylor
F Box 410
III Belton, Texas

Singleton, J. R. 49
Project Leader, Texas G. F. & O. C.
Box 241
V Rockport, Texas

Sivells, Mr. H. C. 46
Chmn. Biology Dept.
A Box 383, S. U. Station
II Georgetown, Texas

Skelley, Mrs. Rose V. 48
Biology Dept.
2631 Wichita
Houston, 4, Texas

Skrabanek, Robert L. 49
Dept. of Ag. Eco., A & M
College Station, Texas

Smith, Bishop A. Frank 46
Resident Bishop of Houston Area
2308 Southmore
Houston, Texas

Smith, Arthur W. 40
Grad. Asst., Dept. of Physics
816 Wood St.
I Waco, Texas

Smith, B. T. 48
Math Instructor & Aviator
2604 - 2nd Street
I Lubbock, Texas

*Smith, Dr. C. S. 37F41
S Prof. of Biology
211 W. Wood St.
II San Marcos, Texas

*Smith, Dr. Cornelia M. 40F
Prof. of Physics
Baylor Univ.
I Waco, Texas

Smith, Dr. Edwin Lee 48
Prof. of Physiology
Univ. of Texas School of Dent.
II Houston, 4, Texas

*Smith, Mr. Elmer G. 29F34
Assoc. Prof. of Physics
F c/o Physics Dept., A. & M.
V College Station, Texas

Smith, G. P. 49
Teacher, Sul Ross
Box 659
Alpine, Texas

*Smith, Dr. Hobart M. 46F47
Asst. Prof.
A Dept. Zoology, Univ. of Ill.
II Urbana, Illinois

Smith, Hugh B. 44
Head Dept. of Biology
211 W. Austin St.
II Nacogdoches, Texas

Smith, Logan D. 47
Asst. Prof., Bio.
Box 164, Baylor Campus
II Waco, Texas

Smith, Rex M. 46
S 1410 W. Main
IV Dothan, Alabama

*Smith, Dr. T. V. 46F49
Maxwell Prof. of Citizenship & Philo.
F Syracuse Univ.
III Syracuse, 10, N. Y.

*Smith, Mr. Victor J. 30F31
Teacher of Industrial Ed.
A 906 East Ave. D
III Alpine, Texas

Solomon, Dr. T. R. 48
Prof. of Political Sci.
Prairie View A. & M.
III Prairie View, Texas

Somers, George Brooks 49
Assoc. Prof. & Head Dept. Geology
4380 Wheeler Ave.
IV Houston, 4, Texas

Spann, Dr. Robert J. 48
Chiropractor
145 Davis Court
II San Antonio, 9, Texas

*Speer, Mr. O. G. 44F46
S Principal, Fairbanks Elem.
IV Fairbanks, Texas

Spence, Miss Agnes Telfer 36
Biology Teacher
A Ball High School
II Galveston, Texas

*Sperry, Dr. John J. 42F
Assoc. Prof. Biology, A. & M.
A Box 4922
II College Station, Texas

Sperry, Mrs. Mabelle E. 48
Teacher Science, Houston Ind. Sch.
1209 Rosedale Ave.
II Houston, 4, Texas

*Sperry, Dr. O. E. 36F38
Prof. Range & Forestry
F A. & M. F. E. 24
II College Station, Texas

Spice, Mr. Wm. H., Jr. 46
S Consulting Geologist
2101-03 Alamo Nat'l. Bank Bldg.
IV San Antonio, 5, Texas

Squire, Dr. Charles F. 49
Physics Dept.
Rice Inst.
Houston, Texas

Stangel, W. L. 47
Dean Div. of Ag.
Texas Tech.
II Lubbock, Texas

Stephens, I. K. 46
S. M. U.
III Dallas, 5, Texas

*Stephens, Dr. Wm. R. 30F33
Chem. Prof. & Head Dept.
F Chem. Dept. Baylor Univ.
I Waco, Texas

Stern, Dr. J. N. 47
Aramberri 1070 Pte.
II Monterrey, Nuevo Leon, Mexico

Stone, Dr. Charles T. 46
S Univ. of Texas Med. School.
Galveston, Texas

*Strandtmann, Dr. R. W. 45F46
Entomologist Biologist
A Texas Tech
II Lubbock, Texas

Street, Paul F. 49
Asst. Prof. Biology
1318 Hunt St.
II Commerce, Texas

Sulkin, S. Edward 47
Prof. Bact. & Immunology
2211 Oak Lawn Avenue
Dallas, 4, Texas

Sullivan, Archie W. 49
Asst. Prof. Ag. Eng.
Box 114, Texas Tech
II Lubbock, Texas

Sutherland, Robert 49
Director Hogg Foundation
U. of T.
Austin, Texas

*Svensen, Dr. Carl L. 30F35
Exec. Sec.
A 912 Tribune Bldg.
I Austin, Texas

Swann, Dr. Howard 46
Med. Sch., Univ. of Texas
II Galveston, Texas

Tallmadge, G. A. 48
Student
326 N. Austin
II San Marcos, Texas

Tapp, Paul F.
Chemist, Chemical Engineer
5224 Pease St.
I Houston, 3, Texas

*Taylor, Dr. I. T. 44F46
Co. Supt. of Schools
II Edna, Texas

Taylor, Josiah 46
P. O. Box 2099
I Houston, Texas

Taylor, Wayne 47
S Wharton Co. Jr. College, Box 283
Wharton, Texas

Telford, Ira Rockood (Dr.) 48
Prof. Anatomy
Univ. of Texas Sch. of Dent.
II Houston, 4, Texas

Terrill, Mr. J. V. 46
S Geologist
Box 1461
IV Midland, Texas

Thein, Prof. Louis P. 49
Prof. Physics & Head Dept.
A St. Mary's Univ.
I San Antonio, Texas

Thiers, Harry D. 47
Instructor, A. & M.
Box 5367
II College Station, Texas

Thomas, Cullen S. 47
S 6601 Hunter's Glen Rd.
Dallas, 5, Texas

Thomas, John Wylie 49
Chem. Prof.
Box 541, Tarleton Station
I Stephenville, Texas

Thompson, Evan G. 46
S Geologist
2030 Milford
V Houston, Texas

Thompson, Mr. R. R. 46
Pet. Geologists, Hill & Hill
1607 Frederick St.
IV Fort Worth, Texas

Thompson, S. A. 46
Vice Pres. & Mgr. Land & Exp.
P. O. Box 900
I Dallas, 1, Texas

*Tidwell, Dr. Herbert C. 37F
Prof. of Biochem. & Chmn. Dept.
F 4228 Stanhope
I Dallas, 4, Texas

Tillman, D. M. 49
Student, Univ. of Houston
706 Eleanor St.
I Houston, 9, Texas

Tinney, William H. 49
Lecturer
3312-25th St.
II Lubbock, Texas

Tinsley, Willa Vaughan 47
SWTSC., P. O. Box 412
San Marcos, Texas

Titterington, George A. Jr. 47
315 Hollywood Ave.
Dallas, 11, Texas

*Travis, Maury M. 41F
Consulting Geologist
726 Denver Nat'l. Bldg.
IV Denver, 2, Colorado

Trentham, Shannon Otis 49
Biology Prof.
Box 244, H. S. U.
II Abilene, Texas

*Trochta, Sister M. Berenice, CDP
Instructor Biology 39F46
Our Lady of the Lake College
II San Antonio, Texas

*Trotter, Dr. Ide P. 38F46
Dean of Grad. School, A. & M.
A c/o Graduate School
II College Station, Texas

Turner, Guy Norman 49
S Geological, Clerical
1110 West Drew Ave.
Houston, 6, Texas

*Uhrich, Dr. Jacob 46
Biology Dept.
A Trinity University
II San Antonio, Texas

*Ulrich, Dr. Floyd Edward 47F49
Assoc. Prof. Math
F Math Dept., Rice Institute
I Houston, Texas

*Underwood, Dr. R. S. 38F
Teacher of Mathematics
F 2220 Broadway
I Lubbock, Texas

Upson, Mr. M. E. 46
Chief Paleontologist, Gulf Oil Co.
Box 1290
IV Fort Worth, Texas

Varvel, Dr. Walter A. 46
Prof. of Psychology, A. & M.
Box 4732
III College Station, Texas

Vaughan, Mr. Wm. H. 46
S Supt. Gas Util. Dept.
P. O. Box 1404
IV Houston, 1, Texas

*Vezey, E. E. 34F47
Teacher, A. & M.
Box 247 F. E.
I College Station, Texas

Vladykov, Vadim-D. 49
Biologist & Dir. Lab.
Dept. of Maritime Fisheries
Parliament Bldg.
Quebec, Canada

*Von Hoover, Dr. C. E. 48F49
Consulting Chemist, Pharmacolog.
F 838 Hot Wells Blvd.
I San Antonio, Texas

von Schwanitz, Dr. Charles 48
Editorial Consultant, Guardman Pub. Co.
808 Taft St.
III Houston, 6, Texas

Waddill, Mr. A. W. 47
S Vice Pres. Houston Oil Field Mat.
P. O. Box 2589
V Houston, 1, Texas

Wagner, Robert P. 43
Asst. Prof.
Dept. of Zoology, U. of T.
I Austin, Texas

Waldschmidt, W. A. 46
Argo Oil Corp.
P. O. Box 1814
IV Midland, Texas

*Walser, Mr. Paul H. 37F47
S State Coordinator, Soil Con. Ser.
P. O. Box 417
V Temple, Texas

Walter, Mr. Robert C. 48
Science Instructor
I Route 2
Fredericksburg, Texas

Wapple, Albert R. 30
Assoc. Prof. Math. & Bus. Admn.
1300 E. 23rd St.
I Bryan, Texas

Warburton, Mrs. Barbara 44
Teacher, Biology, Zoology
333 S. E. 5th St.
II Brownsville, Texas

Ward, William E. 49
Chem. Prof.
Texas Wesleyan College
I Fort Worth, 5, Texas

*Warmock, Barton H. 46F46
Teacher
Sul Ross St. College
II Alpine, Texas

*Warner, Dr. S. R. 37F
S Biology Prof.
Sam Houston State College
II Huntsville, Texas

Washington, Mr. Walter Owen 47
Civil Engineer
208 Pan American Bldg.
I Brownsville, Texas

Wasson. Mr. Alonzo 47
Rt. 2, Box 170
Austin, Texas

Waters, James A. 46
Sun Oil Co.
Dallas, Texas

*Waters, Lewis 45F46
Prof. of Art App. to Medicine
3802 Maple Ave.
II Dallas, 4, Texas

Watson, Mr. C. W. 49
Chemist, Texas Co.
A 3332 6th St.
I Port Arthur, Texas

Watson, Elizabeth 46
Southwestern Medical College
5618 Bell Ave.
Dallas, Texas

*Watts, Dr. Otto O. 33F34
Head of Chemistry Dept. HSU
F 1442 Lowden Ave.
I Abilene, Texas

*Weaver, Mr. Paul 42F48
S Chief Geophysicist, Gulf Oil
A P. O. Drawer 2100
IV Houston, Texas

Webster, Mr. Grady L. 49
Teaching Asst. In Bio., U of T
Rt. 1, Box 79A
II Cedar Valley, Texas

*Weekes, Dr. Donald F. 44F?
S Assoc. Prof. of Physics
P. O. Drawer 1499
I College Station, Texas

Wegner, Mildred John 47
1124 Church St.
Galveston, Texas

Weinert, H. H. 49
Oil Producer, Banker
II Seguin, Texas

*Weisz, Dr. Stephen 46
M. D., Clinic Div., Beverly Hill Sani.
931-933 Medical Arts Bldg.
II Dallas, 1, Texas

Wendlandt, Mr. E. A. 46
S Div. Geologist, Humble Oil Co.
1130 S. Broadway
IV Tyler, Texas

West, Mr. Fred 49
S Pet. Geologist
IV Bonifay, Florida

West Texas Hist. & Sci. Society 29
Miss Anna D. Linn, Sec'y.-Treas.
Alpine, Texas

West, Thomas S. (Mr.) 46
Mech. Eng. Blanco Oil
2112 Alamo Nat'l. Bldg.
IV San Antonio, Texas

*Whaley, Dr. W. Gordon 47F49
Prof. Botany & Div. Plant Res.
F P. O. Box 1777, Univ. Station
II Austin, 12, Texas

Wheeler, Mrs. Helen R. 44
Flight Instructor
Colonial Hotel Apts.
3600 Camp Bowie Blvd.
Fort Worth, Texas

Wheeler, James A. 46
S Fidelity Oil & Royalty Co.
2010 Second Nat'l. Bank Bldg.
IV Houston, 2, Texas

Whitehouse, Miss Eula 46
Tech. Asst. Herbarium, SMU
Box 739
II S.M.U., Dallas, 5, Texas

Whitney, Dorothy 49
Research Assoc.
U. of T. Med. Branch
II Galveston, Texas

Whittaker, Anne 48
Teacher, Sul Ross
A Holland Hotel
III Alpine, Texas

Wiese, Hilda F. 45
1128 Ave. E.
Galveston, Texas
Wiesen, Thomas F. 49

Prof. Economics
Texas Tech
Lubbock, Texas

Wilcox, Mary 40
Math Instructor
1202 Univ. Avenue
I Georgetown, Texas

*Wilde, H. Dayton 46F48
3013 Avalon Pl.
IV Houston, 19, Texas

Wilks, Syrrel S. 49
Prof. Biology
SWTSC
II San Marcos, Texas

Williams, Mr. E. Darrell 43
Consulting Geophysicist
Box 468
I Lander, Wyoming

Williams, Herman F. 49
Lecturer in Ag. Eng.
Box 193, Tech Station
I Lubbock, Texas

*Williams, Mr. Myron L. 39F
Prof. of Eco. & Bus. Admn.
Box 23, S. U. Station
III Georgetown, Texas

*Williams, Dr. O. B. 49
Prof. of Bact., U of T
F Box 1585, Univ. Station
Austin, Texas

*Williams, Prof. Roger 43F46
Prof. of Chem. Dir. Biochem. Inst.
F Chem. Dept., Univ. of Texas
I Austin, Texas

Williamson, W. L. 49
Dist. Agt. Extension Ser.
Ag. Bldg., Texas Tech.
Lubbock, Texas

Willingham, J. J. 49
Prof. of Dairy Manufacture
Texas Tech
II Lubbock, Texas

Willingham, J. Roy Jr. 49
Teacher, Abilene Christian Col.
Station A, Box 588
II Abilene, Texas

Wilson, Mr. F. Wayne 45
Geologist, Am. Rep. Corp.
1817 Pet. Bldg.
IV Houston, Texas

*Wilson, Mr. John H. 43F46
Geophysicist-Independent Exp. Co.
1411 Electric Bldg.
I Ft. Worth, Texas

Wilson, Bro. Raphael, C.S.C. 48
Catholic Educator, Biology
St. Edward's Univ.
II Austin, Texas

Wilson, Miss Velma M. 38
Teacher & Head Dept. of Science
1020 Palm Blvd.
I Brownsville, Texas

Wilson, William B. 49
Rockport, Texas
Winans, Henry M., M. D. 47
S 3825 Beverly Dr.
Dallas, 5, Texas

Winebrenner, O. E. 45
Dean of Science Dept., Howard Payne
903 Rogan Ave.
I Brownwood, Texas

*Winters, Dr. Jet C. 33F33
Teacher of Home Eco.
3004 Clearview Road
II Austin, 21, Texas

*Winton, W. M. 33F33
Teacher
T. C. U.
II Fort. Worth, Texas

*Witt, Dr. Paul C. 34F39
S Prof. Chem. & Head Dept. Nat. Sci.
E 811 East N. 16th St.
I Abilene, Texas

*Witt, Paul E. 34F36
S 3417 Shenandoah
Dallas, 11, Texas

Wolf, Mr. Albert G. 43
Mining Eng. & Geologist
1009 2nd Nat'l. Bank Bldg.
IV Houston, 2, Texas

Womack, Mr. K. E., Jr. 49
Research Asst., Tax Research Assn.
1025 Cotton Exch. Bldg.
III Houston, 2, Texas

Woods, Dr. Ozro T. 47
3501 Harvard St.
Dallas, Texas

Woods, Mr. R. D. 46
Paleontologist, Humble Oil
1037 A Humble Bldg.
IV Houston, Texas

Wooten, Mrs. Mattie Lloyd 46
Dir. Dept. Sociology, TSCW
1113 N. Locust St.
III Denton, Texas

*Worley, Gordon, Sr. 45F46
Special Supervisor
Dept. of Education
III Austin, 11, Texas

Wright, A. C. 46
524 Woldert St.
IV Tyler, Texas

Wright, Dr. E. R. 49
Head, Analytical Dept. Tex. Div. Dow Chem. Co.
1515 West Broad
I Freeport, Texas

Yocum, W. W. 49
Horticulture Teacher
Texas Tech.
II Lubbock, Texas

York, Christopher 46
Teacher
Box 1915
I Austin, 12, Texas

*Young, Dr. Arthur W. 38F41
Prof. Agronomy
Dept. Plant Industry, Texas Tech
II Lubbock, Texas

Young, Dr. Dixie 49
Teacher, TSCW
621 Grove St.
II Denton, Texas

*Young, Dr. Vernon A. 48F48
Teacher & Head Dept. of Range and Forestry
F Range & Forestry, A. & M.
II College Station, Texas

Zingery, W. W. 49
S Owner, Zingery Map Co.
1413 City Nat'l. Bank Bldg.
Houston, Texas

Zoffman, George F. 49
S Mining Engineer
1120 Esperson Bldg.
Houston, Texas

Zotos, Dr. G. A. 49
S Process Engineer
2528 Broadway
I New York, 25, N.Y.

LIBRARIES

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Grand Isle, La.

EDITORIAL NEWS AND NOTES

ACADEMY OF SCIENCE NIGHT at Hardin-Simmons University was on April 28, when the Hardin-Simmons Science Club entertained the chapters of McMurry College and Abilene Christian College, and state officers in a joint meeting and program. The meeting was in honor of a visiting group of scientists from Houston, Galveston, and College Station. Two hundred twenty-five students were present to make the meeting an outstanding success.

The program consisted of two addresses—one by Dr. J. Brian Eby, president of the Texas Academy of Science, who gave an illustrated lecture on "Geophysics and Geology in Oil Exploration." His address was followed by a short social hour when refreshments were served by Mr. Charles Tandy and Miss Rita Branscums's committee of entertainment of Hardin-Simmons Science Club. On re-assembling, Dr. J. G. Sinclair, president of the Conservation Council of the Academy and professor of anatomy at Texas University Medical School, gave a very interesting address on "Some Adventures in Research." These speakers had been able to fly to Abilene through the courtesy of Farnsworth and Chambers, construction engineers of Houston, who furnished the plane for the trip. They were accompanied by other Academy officials—Dr. Charles LaMotte, counselor of the Collegiate Academy; Dr. Clifton C. Doak, former counselor and professor of biology at Texas A&M; Mr. Lyle Blankenship, collegiate state president, also of Texas A&M; Dr. Paul Witt, sponsor of Abilene Christian College Science Club; and Dr. W. Norton Jones and Mrs. Marta Ve Fox, sponsors of McMurry College Science Club.

The meeting was held in one of the spacious classrooms of the new Abilene Hall at Hardin-Simmons and it was completely filled by a large and appreciative group of Abilene scientists. We highly recommend this type of program in the various colleges of the State to increase the interest in Academy affairs throughout Texas.

THE COPANO RESEARCH FOUNDATION AND THE TEXAS GAME, FISH AND OYSTER COMMISSION are cooperating on an investigation of the habits and life history of trout, redfish and flounder.

ARRANGEMENTS HAVE BEEN COMPLETED for the Annual Meeting of the Texas Academy of Science. The meeting will be held at the new Fondren Library, the Rice Institute, Houston, Texas, December 2nd and 3rd.

Dr. William V. Houston, President of Rice, has cordially invited The Texas Academy of Science to come to Rice and the Executive Council were glad to accept.

The new library is admirably adapted to accommodate all sessions for the Senior Academy, Collegiate Academy, and the Juniors.

The President's dinner will be on the campus in the Rice Institute main dining hall. We have been quoted a price not to exceed $2 per plate for this dinner.

Dr. C. M. Pomerat, Executive Vice President, is responsible for directing and organizing the program. Dr. Charles F. Squire, of the Physics Department, Rice Institute, is chairman of the local arrangements and will be assisted by Mr. D' Arcy Cashin and Dr. L. W. Blau. The general theme for the meeting will be:

"WHAT SHOULD TEXAS EXPECT FROM SCIENCE?"

The general session on Friday afternoon, December 2nd, will be devoted to this topic. (Section programs are not to conflict with the Friday afternoon symposium.) Section vice presidents will arrange their respective programs and so far as feasible follow the central theme of the convention; but unrelated papers will be acceptable.

Registration will be in the main lobby of the Fondren Library of the Rice Institute; and room reservations will be at your own choice.

EDITORIAL

With this issue we have attained what we hope will be the final format of the Journal, at least in so far as the typography goes. There have been some suggestions in regard to the cover. However for one person objecting to the gray three persons have complimented us on it. Tan is not nearly so attractive. We would be glad to have your comments on it.

We have been considering enlarging the size to 6½ x 9¾ inches. This is the same size used by Copeia, The Journal of Mammalogy and others. We will also be glad to hear from the membership on this, as we want this to be your Journal.

In this number, at the end of the paper by Mr. York, will be found suitable editorial apologies for the inclusion, through mistake in composition, of two maps prepared by him, in an earlier number with a paper of very similar title. We are sorry that this occurred. Nevertheless, it presents a very trenchant edge to the request that we have constantly made in all issues of the Journal—*Please put your name, the title of the paper and the figure number prominently on all plates accompanying papers* because, while you know perfectly well where they go in your paper, the editor and the printer have in this particular issue some thirty or forty figures and plates, the majority of which had, when they came to us, no identifying mark. It is one of the duties of the editor, of course, to key these to the various papers and see that they are not lost, misplaced or stolen, but it would be much simpler for the editor, who, believe it or not, has a great deal to do, if you would label these plates so that the chances of getting them mixed up will be kept at a minimum.

There is another point that we would like to bring to your attention. One of the papers in the symposium on tracer elements, although presented last December, arrived at our desk only some three or four weeks ago. The task of publishing a quarterly journal is a good deal more onerous than the task of publishing an annual. The press of other duties on the part of the editorial board does not allow the members to enter into extended correspondence in order to run down missing papers that were not turned in when presented, and which have floated around in the hands of the author for three, five or six months. These papers should come in as early as possible, in order that we may be able to plan the issues properly and to present a balanced quarterly that you will enjoy.

Moreover, *please put your name, address and affiliations at the head of the paper beneath the title.* Very often when papers are turned in to chairmen of the various sections there is nothing on them but a name. Sometimes there is not even a name and, if the accompanying letter has been lost during the travels of the manuscript, and the program happens to be incorrectly printed, which has happened, then it is the devil's own task to get the galley proof and manuscript to the author for correction and get it back in time for publication.

These are little things that you can do very easily that would make the task of editing the Journal immeasurably simpler for everyone concerned and will produce a better Journal for you.

DIRECTIONS FOR THE PREPARATION OF MANUSCRIPTS

1. Manuscripts should be submitted to The Editor, Texas Journal of Science, Box 867, Rockport, Texas. Manuscripts may be subject to minor editorial alterations in order to conform to the general style of the Journal. All manuscripts must be typewritten and double spaced with wide margins. The fact that a footnote is usually printed in small type, closely spaced, does not make it any less likely to need correction than any other portion of the manuscript, and the practice of some authors to single space such interpolations makes it exceedingly difficult to make the necessary editorial corrections.

2. Each manuscript must be accompanied by two copies of an abstract, not more than two hundred and fifty words in length. If the editorial board finds it advisable, the abstract may be published instead of the paper. If the paper can be much improved or condensed the editor may return it for such changes.

3. The following form should be adhered to in typing any paper:—

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4. References or bibliographies should be arranged alphabetically at the end of the article, without numerical designation. References in the text should be by author's name and date of publication.

The use of footnotes should be avoided wherever possible. These are troublesome to the editor, and a nuisance to the printer, as they have to be properly spaced in the composing, which takes increased time and raises costs.

5. A typical bibliographical entry should be as follows:—

Doe, John, and **W. C. Rowe**—1943—How to prepare a bibliography. Tex. J. Sci. **6**(2): 1-13, 3 figs., 2 pls.

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The above is a standard form that makes it immeasurably easier for the editor to handle. Please be accurate about the volume, part and page numbers. A poor bibliography is worse than none at all.

6. Cuts and other figures will be accepted up to the limit of the Academy publishing budget. However, for the present it is desirable that they be kept at a minimum. All illustrations should be in black and white for zinc cuts where possible. Half-tones require special paper and, if too expensive, may be charged to the author. Drawings and illustrations should be carefully prepared for reproduction. Legends should be precise and included with the drawing and illustration.

7. Tables should be limited to necessary comparisons and, if possible, should be clearly typed or hand lettered ready for photography. Printing tables is very expensive.

8. Arrangements are being made with the publisher to furnish three sets of proofs to the editor so that one may be sent to the author for proof reading before publication. However, until we are able to get a sufficient mass of type set ahead, it will be very necessary to return this corrected proof and manuscript promptly or the paper will have to be omitted from that issue of the quarterly and another substituted on which the author has been more prompt. Moreover, remember that extensive changes in the subject matter of the paper after the type has been set are expensive, and time consuming. If such changes must be made the expense will, of necessity, fall on the author.

9. Arrangements are being made to furnish reprints. The following schedule of prices will apply, subject to change. They are identical with those charged by Copeia, the official Journal of the American Society of Ichthyologists and Herpetologists. It will be necessary for a check to accompany orders for reprints, which may be returned with the proof. This, of course, does not apply to institutional orders, but only to Academy members ordering personal copies. This keeps bookkeeping at a minimum and also keeps the publisher in a good humor. It is felt that this is the most desirable way to handle the matter despite the fact that in the past it has been the custom for the editor to obtain the reprints from the publisher and then collect from the individual member.

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10. **Above all, be sure name of author, title of paper and author's affiliations are on the Ms itself, also on all cuts.**

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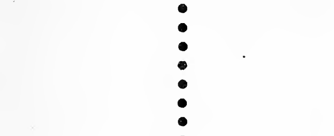

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The Texas Journal of Science

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SCIENCE, INDUSTRY AND THE SOUTHWEST

J. Brian Eby*
Consulting Geologist
Houston, Texas

The writer is indebted to the Twentieth Century Fund for its permission to use freely material contained in its pamphlet "USA, Measure of a Nation. A Graphic Presentation of America's Needs and Resources" by Thomas R. Carskadon and Rudolph Modely, published by MacMillan Company, New York, 1949. Acknowledgment is also made to The Office of Rubber Reserve of the United States Government for reproducing pictures of their plant at Baytown, Texas, operated by the Humble Oil and Refining Company. Photographs and data were furnished by the Texas Gulf Sulphur Company; the Dow Chemical Company; Shell Oil Company, the Texas Company and the Humble Oil and Refining Company, for which the author is grateful. The Southwest Research Institute, and Mr. Vernon Frost of Houston, provided special Kodachromes, and other helpful information. The author especially wishes to thank the Humble Oil and Refining Company for assistance in preparing the photographs and charts for slide reproduction.

In this time of world-wide political and economic confusion, it is appropriate to examine the role of science, and the role of industry in the shaping of our private lives. Under the stimulus of the recent war, the scientific talents of the nation were organized and great sums of money placed at their disposal. From this combined and subsidized research came, not only the atomic bomb, so well publicized, but a vast stream of new scientific applications to industry. These technological contributions touched all phases of our lives; agricultural, business and manufacturing.

So complete and thorough has been this introduction of science into industry, that the standard of living in the United States has been elevated above that of any other nation in the world. In comparing ourselves with other great countries, and in particular Russia, I should like to point out that the United States, with 7% of the world's population, and 6% of its land surface, produces 46% of the world's electrical energy, 61% of its oil, 32% of its total factory output and 30% of its railroad mileage. Against these figures Russia has 8.8% of the world's population, 14% of its land area, 5% of its factory production and 6.2% of its railroad mileage. Our country has 1749 newspapers against 28 for Russia.

On this and similar comparisons the United States, at the present moment, is head and shoulders above any other country on the face of the earth in productive ability. While this is obviously in our favor, there are the attendant dangers that our very preeminence will induce self-complacency and retard our further progress. It has been the history of many great nations in the past, starting with Egypt, 6000 years ago, that once the necessities of life were supplied, the genius for further activity is stilled.

It is of interest to review briefly the spectacular growth of our country, and how the introduction and development of machinery brought our civilization to its present peak. From 1700 until the present year our forest lands have diminished, and our crop lands have steadily increased. With the aid of machinery, we are now cultivating over 400 millions of acres of land.

* Retiring President, Texas Academy of Science, 1404 Esperson Building, Houston, Texas.

Our population has grown from 30 million in 1860 to 145 million at the present, with large increases by immigration chiefly from European countries up to and including the decade of 1920-30.

In the year 1850, it is estimated that 79% of all productive power in this country had its source from animals as against 15% man power, and 6% machine power. It is now estimated that these percentages will be 1% animal power, 3% man power and 96% machine power with eight times the value of goods produced in 1960 than at the earlier date. Translating this output into man hour figures, it means that one man produced 25c worth of goods per hour in 1850, and $1.60 worth of goods by the end of the coming decade.

The trends in foreign trade give a definite bearing on the present status of our industrial development. Within the last decade we are exporting in an increasing quantity, cotton, machinery, automobiles, iron and steel, shipping and freight, and interest and dividends. At the same time our imports of rubber and silk are declining but copper, tin, petroleum, wood, paper, and United States travel abroad is rapidly increasing. The war-encouraged manufacture of synthetic rubber, nylon to replace silk, artificial cryolite to replace the native cryolite in aluminum making, all have greatly disturbed the dollar trade balance of the world.

In the general industry set up of our nation, it is pertinent to call attention to our income and expenditures. Our yearly per capita income, based on 1947 prices, has risen from $870.00 in 1929, to a war-time peak in 1944 of $1350.00, with an estimated total for 1950 of $1140.00. While our personal incomes have risen, our total general government expenditures, including local, state and federal, has risen from 23.1 billion in 1941, to an estimated 52.2 billion in 1950, and 58 billion in 1960. Huge segments of this increase are taken up by social insurance, interest on debt, war and defense, transportation, and to a lesser extent, on schools. Our expenditure for welfare from 1941 to 1960 is the only major item of government expense which will probably show a decrease.

The trend in capital expenditures on the part of the country as a whole shows a steadily increasing tendency to move from private investment to public investment, a trend which in the writer's opinion, is to be deplored. In productive facilities, public participation in 1929 was 4%, and by 1960, it is estimated to rise to 9.4%.

With this picture of the national industrial set up in mind, let us look to the shift in industrial importance in the United States from the year 1919 through the past war, as affecting the various major sections of the United States. The greatest single beneficiary has been the South Central region, embracing largely Texas and Louisiana areas. The northeastern section of the United States in 1919 contained 46.6% of the industries of the country. By the close of the war its relative rank had shifted to 23.8% and the Texas-Louisiana area had increased in the same period from 5.6% to a total of 16.7% of our national industry.

Petroleum and its products set the pace for every industry in the Southwest. In Texas alone, the annual income to the economy of the state reached 3 billions of dollars and the oil companies have expended over twice this amount in new equipment and installations alone within the last three years. To keep this industry on top, science is participating in all phases of its activities. This is particularly true in the exploration for new oil reserves.

The vast area of the continental shelf of the Gulf of Mexico is now being explored for oil structures by means of the airborne magnetometer, the gravity meter, and by seismograph with help of radar for location of stations in the water. Already one billion dollars has been invested in this program by a number of the larger oil operators, and up to the present time, approximately one million dollars worth of oil has been recovered. It is anticipated that it will require an additional five years before these surveys return a profit on the venture.

It is the chemical industry to which the Southwest points with equal pride. Within the past few years investments in the chemical industries have totaled over 700 millions of dollars with an annual payroll exceeding eighty-nine million dollars. The impact of science and the new technological procedures that have been made, made it highly desirable for many of the Atlantic seaboard chemical companies to build new plants, near the location of source materials, such as the hydrocarbons of the Gulf Coast area rather than rebuilding their old plants back east.

One of the outstanding chemical developments in the coastal area in 1948 was the establishment of the first commercial synthetic glycerin plant in the world by Shell Oil Company and Shell Chemical Corporation on the Houston Ship Channel. This plant, now in operation, won for these companies, and the Shell Developing Company, the 1948 award for Chemical Engineering Achievement.

The Dow Chemical Company is operating, at Freeport, one of the largest magnesium from sea water plants in the world. This company, in addition to magnesium, produces a number of other hydrocarbon chemicals ranking it as one of the largest producers in this region.

The development of artificial rubber has indeed been one of the foremost scientific achievements applied to industry. It started as a war-time measure. The making of rubber from hydrocarbons was intended to relieve this country from the necessity of importing natural rubber and it now develops that the artificial rubber can be made to serve industry even more satisfactorily than the natural product. The United States Rubber Reserve owns the plant at Baytown and the Humble Oil and Refining Company operates it. The very fact that artificial rubber is superior in many of its uses to natural rubber insures the continuance of this industry in the Gulf Coast area.

Sulphur is now being produced in this region, principally from Newgulf, Fort Bend County, Texas, by the Texas Gulf Sulphur Company, and Lake Washington, Louisiana by the Freeport Sulphur Company. The sulphur production from this area represents approximately 90% of the world's output.

The application of science to agriculture in the Southwest has not been overlooked, and there are four independent laboratories in the State of Texas alone designed to improve cotton and its products. This year is historic in that it is the first year a bale of cotton was raised in Culberson County, West Texas, representing the last county in the entire state to have entered, at one time or another, the cotton raising industry of Texas.

Within recent years stock raising in the Southwest has had considerable attention on the part of the scientists in the development of breeding, feeding, and new grasses for the range. Many of the ranchers in Teaxs are now cooperating with representatives of the Department of Agriculture of the Texas A & M College and of the Southwestern Research Institute in San Antonio. The progress, as indicated by improved cattle and better range land has been little short of phenomenal. The Pecan Acres ranch of Vernon Frost of Houston and his Jumbo Brahman bulls and cross-breeds are an excellent example.

In the field of medicine and public health the establishment of the M. D. Anderson Hospital for cancer research in Houston, and the researches of the University of Texas, Medical Branch, at Galveston, have given tremendous impetus to investigators within our midst. Dr. R. Lee Clark, Jr. at the Anderson Foundation is directing the work of the hospital and its publication "Cancer Bulletin," acclaimed by cancer societies throughout the United States. At Galveston, under the direction of Dr. Arild Hansen, significant advances are being made in the treatment of infant diarrhea and by Dr. Truman Blocker of severe burns from industrial accidents.

Both institutes are joining in the search for new antibiotic substances for the treatment of cancer and related diseases. It has been pointed out that following the first world war, medical science has reduced drastically deaths from influenza and pneumonia, tuberculosis and diarrhea-enteritis, but heart diseases, cancer and motor accidents now rank as the foremost killers. Following Dr. Alexander Flemming's discovery of penicillin in 1928, and Dr. Selman Waksman's equally important discovery of streptomycin in 1939, two new antibiotics were announced within the past year. These were aureomycin, by Dr. B. D. Dugger, at the American Cyanamid Company's Lederle Laboratories, Pearl River, New York, and chloromycetin, by Dr. P. R. Buckholder, of Yale University. Aureomycin is strikingly effective in rickettsial diseases and chloromycetin is efficient in typhoid fever. The isolation of vitamin B 12, said to be the most potent drug in the world, may well wipe out the dread disease of pernicious anemia. However, this drug is not yet available on the market. No antibiotic or drug has yet been found to be effective against the viruses or certain forms of cancer, and to this end many of the research laboratories are assigning their experts.

The medical profession can point with considerable pride to these great accomplishments. The life span of the average citizen of our country has increased steadily from 40 years in 1850, in Massachusetts, to an expected life span of 69 years in the decade from 1950 to 1960. The cost of medical attention to the average citizen is about 4¢ out of every dollar that we spend. In the writer's opinion, the secret of this achievement is the initiative and enterprise of private practice, and freedom of action in research and employment.

In the field of transportation the scientist has turned his attention to the development of more speed, more efficiency and more luxuries in travel.

With this in mind the railroads are turning to Diesel engines, 5400 horsepower units, for more efficient locomotion. The Southern Pacific railroad and the other major operators in the Southwest are joining the national trend in the replacement of steam locomotives by gasoline and Diesel electric engines. In 1948 alone, 1397 Diesels were placed on the nation's railroads, raising the nation total to over 8000 Diesel units now in use. This is about one-fifth of all the steam equipment now in service and the railroad's fuel requirements are slowly and inevitably changing from coal to oil.

The greatest gains in transportation in 1948 and 1949 are being registered by the aviation industry. The scientist is continually and energetically at work perfecting newer, better and bigger equipment to fly the air lines. Among these planes the Boeing Stratocruiser, Lockheed Constellation, and the Douglas DC 6 are among the top contenders. Jet planes for civilian travel are right around the corner.

It may surprise some to know that in 1948 the air lines carried 52% of all over-seas passengers, to and from the United States, a total of 1,810,061 persons. For the same year the air lines carried 63% of the over-seas mail against 37% that went by ship. It should be pointed out, however, that in 1948 many of the great ocean liners were not yet restored to active service, and these percentages will probably not hold through 1949.

Even more surprising however, is the statement of A. P. Adams & Associates of New York, aviation consultants, that for the month of May, 1949, the domestic air lines covered more passenger miles of travel than all the pullman and parlor cars in the service of the domestic railroads. Incomplete figures indicated that June, 1949, would also favor air line travel over first class railroad travel.

To advance and facilitate the technical and industrial research in the Southwest, vast new scientific laboratories have been established. The Shell Oil Company was one of the first to build an extensive research plant for chemistry and geophysics at Houston. The Gulf Oil Company, the Texas Company, and Humble Oil Company, and several of the smaller operators maintain large investigative staffs in both chemical and geophysical research.

The Texas A & M College has established a research foundation covering a wide range of projects from agriculture to physics. The medical research department of the University of Texas has already been mentioned.

The privately endowed Southwestern Research Institute in San Antonio is a magnificent effort to further scientific research, in many phases of agriculture and mechanics. On its spacious Essar Ranch near San Antonio, chemical, physical and mechanical laboratories are devoted to a wide range of research problems. A service for inventors is offered the public. Live stock and farming comes in for special attention. Mr. Tom Slick, of San Antonio, the founder of the Southwestern Research Institute, is to be warmly congratulated in the fine plant he has created.

This union of science and industry has made possible the remarkable development of the Southwest area in particular, and the United States as a whole. We must recognize the fact however, that the mere building of these plants and the raising of our pay rolls is not sufficient in itself to meet the serious competition of scientific thinking that our potential world competitors might bring to play against us. It has been said that few new scientific techniques have been discovered in this country in recent years, but that all of the staggering development of the last decade has been largely the application of well known scientific principles to industry. Our greatest scientific contributions have occurred during the period from 1872 to 1918. Dr. Frederick C. Beach, late editor of the Scientific American, and L. H. Campbell, of the United States Patent Office, compiled a list of nearly 400 of the world's foremost inventions and discoveries covering the period of time from 1725 to 1918. According to their list 168 were made by natives of the United States; 92 were made by English inventors; 45 by the French; 40 by the Germans; 3 by Italians and 1 from Russia. This list was published in the 1940 edition of the American Encyclopedia.

While the odds seem overwhelmingly in our favor we should not fail to point out that countries such as Russia now have the initiative of necessity on their side. The writer believes that our vast accomplishment can only be preserved in the same manner. Let us not be like the Egyptians of old, and raise pyramids to crush us whether these pyramids be of stone, or governmental control, or direct dictatorship.

The American public must be made aware of the close relationship between the aims and accomplishments of science and its application to the industries which control our American way of life. We must remain active in a land of plenty, work in spite of abundance, and protect our individual freedoms. If we can do that, we need fear no power on earth.

A CENTURY OF PROGRESS FOR AMERICAN WOMEN

L. H. Hubbard
President, Texas State College for Women
Denton, Texas

1948 is a year of unusual significance to American women. It marks the close of a century of struggle by them to secure the social and political status to which in justice they have been entitled.

Someone has said that the historian of the future will describe the last one hundred years as being distinguished by three great revolutions; first, the industrial revolution and the development of power machinery; second, the political revolution discarding the theory of the divine right of kings and emphasizing the trend toward democracy on the one hand and totalitarianism on the other; third, the change in the status of women. All three are inter-related. For instance it was the invention of the cotton gin by Eli Whitney that took weaving out of the American home and into the textile mills, where women were given employment and so started them on their way to enter the world of business and the professions. And when they finally achieved the vote in 1920, through the passage of the 19th Amendment to the Constitution, democracy had taken another great step forward.

One hundred years ago American women had no legal rights; their children were under the sole guardianship of their husbands; even any wages they might earn were the sole property of their fathers or husbands. They were not allowed to speak in public, and lost reputation if they attempted to do so. It was this obstacle that made Mary Lyon's task so difficult in raising funds for the establishment of Mt. Holyoke Female Seminary in the winter of 1835, and if it had not been for the devotion to her cause by a small group of New England ministers, who permitted her to speak in their churches, she could never have been heard. And even years later, when Susan B. Anthony attended a meeting of teachers in Rochester, New York, in 1853, and asked for permission to speak, her action produced a sensation, and the men delegates debated the issue for a long time before finally according her the privileges of the floor, and that by a narrow majority.

The first humanitarian movement in which American women publicly interested themselves was the abolition of slavery, and it was in this cause that the first woman's political club was organized in 1833, the Philadelphia Female Anti-Slavery Society. The first public address by a woman was made in America, also in Philadelphia, in 1836, by Angelina Grimke. She was met with hoots and jeers, but she held her ground and was finally allowed to finish. Then in 1840 a group of American women, including Lucretia Mott and Elizabeth Cady Stanton, were elected delegates to a world anti-slavery convention to be held in London. But when the convention opened and it came to the question as to whether or not women delegates should be admitted as members, a furious all-day debate resulted, with the vote finally taken against seating the women, and they were placed behind a curtain, so they would be entirely separated from the men delegates.

The treatment accorded these American women in London brought them back to this country with a firm resolution to see that such an outrage would not occur here. They began talking about a woman's rights convention. But public opinion even in the United States was so much against them that they could make little progress. Each time they made any suggestion toward a meeting the press especially was antagonistic. But finally, in 1848, one hundred years ago, again led by those two stalwarts, Lucretia Mott and Elizabeth Cady Stanton, the first woman's rights convention was organized.

The convention opened in Seneca Falls, New York, July 19, 1848. The attendance was meager, but those who were there were high in their resolution. Following the pattern of the Declaration of Independence, the convention first adopted a recital of the wrongs and injustices which American men had forced their sex to endure. Among them were the following:

> "He has never permitted her to exercise her inalienable right to the elective franchise.
> "He has withheld from her rights which are given to the most ignorant and degraded men—both natives and foreigners.
> "He has made her, if married, in the eye of the law, civilly dead.
> "He has taken from her all rights of property, even to the wages she earns.
> "He has made her, morally, an irresponsible being, as she can commit many crimes with impunity, provided they are done in the presence of her husband . . ."

This recital of wrongs was then followed by a woman's Declaration of Independence which began with these words: "We hold these truths to be self-evident; that all men *and women* are created equal . . ." Among the rights for their sex they then went on to declare as essential to its well-being, and to which women were, in justice, entitled, were the right of suffrage, the right to hold office, the right to own and control property, to collect and control their wages, to make wills, to practice a profession, to share the guardianship of her children, and to be a witness in court after her marriage. We take these rights for granted now, but in 1848 women had none of them. They are what this past century has brought to them.

The Seneca Falls Convention aroused the news sense of American editors, and, up to the time of the gold rush of 1849 it was the sensation of the hour. Inez Hayes Irwin, in her volume, "Angels and Amazons," states that "the heavier journals attacked it with formidable adjectives and citations from Scripture. The NEW YORK HERALD began that campaign of invective which lasted as long as James Gordon Bennett lived. But to most journalists, the performance was merely funny—such a God-sent opportunity for the newspaper humorist as arises only once in a decade . . . On the other hand, a few radical newspapers took the movement seriously—in especial Horace Greeley's NEW YORK TRIBUNE. This served to draw the topic into controversy, to keep it alive. Within a year, the remotest hamlet knew about the Seneca Falls Convention. And the gale of laughter blew those tiny sparks, smouldering through the country, into flames . . . Before 1852, and 'without the least concert of action', women's rights organizations had sprung up in Ohio, Indiana, Pennsylvania, Massachusetts and Kansas." It was not long until a national organization was formed.

In the meantime the doors of institutions of higher learning were slowly opening to American women. The general public, however, still did not believe in the idea. Many men honestly thought that women were incapable of absorbing college education—that their minds were not developed to that extent—that they had no reasoning ability, and depended wholly on intuition. In New York, in 1819, Mrs. Emma Hart Willard attempted to secure the passage of a law establishing a State college for women. A furious debate resulted, and one legislator shouted, "They'll be wanting to educate cows next." The bill was defeated, and Mrs. Willard was forced to open a private school, the Troy Female Seminary, in 1821. This was the first serious attempt to educate young women beyond the 3 R's stage. This school was later to become Russell Sage College for Women. Mt. Holyoke Female Seminary, still far from being a college, opened its doors in 1837. The first woman's college to be chartered by a State was the Georgia Female College in 1839. But it too was only a preparatory school. The first *real* woman's college, that had a curriculum equal to those of similar colleges for men was Vassar, which opened its doors in 1865. The first state tax-supported woman's college was organized in 1884, the Mississippi Female College and Institute, now the Mississippi State College for Women.

As regards co-educational colleges, it was in 1833 that American women had their first opportunity to secure the benefits of college education. This privilege came to them in that year when Oberlin College, a new institution then being opened by the Methodist Church, at Oberlin, Ohio, opened its doors to women as well as to men on equal terms. But so few opportunities did girls have at that time for securing even a high school education that only four girls entered the first freshman class, and when three of them received their degrees in 1837, a new epoch in the history of woman was begun. By 1850 a number of other co-educational institutions in the mid-West, including some of the state universities, were admitting the few women who were prepared to enter.

The period of the Civil War, even though it did not bring to American women their hoped-for enfranchisement, gave them their first big opportunity to secure a foot-hold in the world of business and the professions. Just as during the two world wars, the arming of American men from 1861-1865 made it mandatory that American women take their places in vocational and technical fields. And, as in the last two wars, the efficiency of these women gave them a foothold in these fields that they did not relinquish after hostilities were ended. The Civil War especially made manifest the ability of the hundreds of volunteer women nurses to alleviate the sufferings of the sick and wounded soldiers. Led by Clara Barton the women quickly demonstrated their usefulness in this new field of service. In tribute to the service which they rendered, President Lincoln said: "I have never studied the art of paying compliments to women, but I must say that if all that has been said by orators and poets since the creation of the world were applied to the women of America it would not do them justice for their conduct of the war."

Now may I point out some of the milestones in your progress that this past century and more has recorded. In the decade from 1833 to 1843, the first woman's club was organized in Jacksonville, Illinois; it was called the Ladies' Association for Educating Females. Ann Wilkins became America's first woman missionary. Sarah Josephus Hale became the first editor of a national magazine, Godey's Lady's Book, and started the movement for our national observance of Thanksgiving. Oberlin College opened its doors to women. Women also entered industry through the cotton mills of New England. In the decade from 1843-1853 came the Seneca Falls Convention. Harriet Beecher Stowe published "Uncle Tom's Cabin." Maria Mitchell was recognized as America's first woman scientist. Between 1853 and 1863 Clara Barton was appointed as a clerk in the Pension office at Washington, thus becoming the first woman to be regularly employed by the United States Government. This was in 1854. During this decade also Antoinette B. Blackwell became the first woman ordained minister, and two other young women of the same name, and who were sisters, Elizabeth and Emily Blackwell, were the first women to receive degrees in medicine. Between 1863 and 1873 Julia Ward Howe wrote "The Battle Hymn of the Republic." Mary A. Livermore became the editor of The Woman's Journal. Between 1873 and 1883 Linda Richards became the first graduate trained nurse in the United States. And it was through Clara Barton's influence that The American Red Cross was founded. Frances E. Willard founded the World Woman's Christian Temperance Union and became the first president of the National Council of Women.

In the field of politics, the struggle which began at Seneca Falls in 1848 moved slowly forward. Susan B. Anthony was soon its acknowledged leader. When the slaves, after the Civil War, were enfranchised through the passage of the 13th, 14th and 15th Amendments to the Constitution of the United States, Miss Anthony and her tireless workers thought surely that the hour for American women had struck, and that now that negro men had the right to vote the Congress would surely propose another amendment to the Constitution, according this same right to women. But she was doomed to disappointment, and it was not until 1920 that the 19th Amendment was finally adopted.

But have American women fulfilled their promise to prove worthy of the ballot? Have they cleaned up politics in this country as they confidently predicted? There is much evidence in the negative. While many American women have displayed a high regard for their privileges as citizens, it is a sad fact that many of their sex have failed to use wisely the political power that has been placed in their hands. On the whole it can be stated that women have not demonstrated their political wisdom, and have not yet earned the political respect of the nation. A woman elected office holder is still a rarity. I would like to call your attention to the words of Carrie Chapman Catt, one of your great leaders of the past generation: "What now, women of America?" she asked. "Another century calls you. Side by side with men citizens it is for you to rejuvenate the republic, revivify its faith and replenish the fires of human freedom . . . With the same consecration to a great cause manifested by the pioneers who set our feet upon the path leading upward, with the same devotion revealed by those who came after and performed the drudgery of weary years, will you, free women of America, lead on to that ideal democracy never yet attained, but which alone can salvage threatened civilization?" What will be your answer to this question, you women of America? I believe that it will be what Mrs. Catt would have wanted it to be ,even though progress, so far, has been disappointingly slow.

My subject for this paper is "A Century of Progress for American Women." And in many ways it has been a record of progress. But there are many who feel that with their political failure there has been a corresponding failure in the field of morals—that women, instead of raising men to their standards of conduct, have lowered themselves to masculine standards of profanity, of drinking, of sex. I believe that these criticisms are not wholly justified. Yet they are not without foundation. There has never been a time more than today when women needed to set the world a good example. And if this is true of women in general, how much more true is it of women who have had the advantages of college training. They should be leading the way.

One thing we can assert with confidence. With its gains and losses, this century has been tremendously significant for the women of America. The girls of today are its product. They have been freed from the shackles of ignorance and prejudice that encompassed them. They have become free in body, mind, and spirit. But they must learn to use wisely their freedom. Above all they must learn the value of discipline. For without discipline the human spirit cannot flower.

SOME PROBLEMS OF ECONOMIC DEVELOPMENT OF LATIN AMERICA

Walter H. Delaplane
The Agricultural and Mechanical College of Texas

The twenty Latin American republics have such a marked diversity in their size, terrain, population, resources, and other characteristics that it is rather presumptuous of one to speak of the problems of development of this area in a short paper. The economy of the River Plate Region embracing Argentina, Uruguay, and Paraguay has long been based on agriculture and livestock. Only in relatively recent times has there been any significant industrial development, and that has been confined almost exclusively to Argentina. In contrast, the economies of Chile, Bolivia, Peru, Mexico, and Venezuela have been founded largely upon mining or the extraction of oil. Brazil, Central America and the Caribbean Island republics have been chiefly agricultural, though in recent times industrial development has proceeded apace in Brazil.

Throughout most of this region living standards have been at a very low level, with the best standard in all probability that prevailing in Argentina, Uruguay and Chile. Productivity per worker has been low, and purchasing power consequently extremely limited. Since World War I much activity has been directed to the industrialization of these areas. This movement was the accompaniment of a growth of strongly nationalistic feeling in most of these states. During World War II, when foreign sources of supply could no longer be tapped for the consumer goods needed and when producers abroad were not in a position to compete with domestic manufacturers, existing manufacturing enterprise grew rapidly, and many new products of national industry appeared on the local market. The expansion of industry in these years has been greatest in Brazil, Argentina and Mexico. Even the smaller republics, however, have been stimulated to finance the undertaking of production of light industry.

Despite the development that has taken place, money wages and living standards remain low throughout virtually all of this area. In Paraguay, for example, in 1946 a skilled worker earned the equivalent of about $1.00 to $1.25 United States money per day. School teachers received about $25.00 per month or less and workers in a managerial capacity earned as much as $75.000 to $100.00 a month. While these wages and salaries are low compared with those of the metropolitan areas in South America, they are indicative of the general level of incomes prevailing throughout a large part of the region. Notwithstanding low wage rates, costs of production have generally been high, owing to the extreme shortage of capital and to the scale of enterprise which was limited by the narrowness of the market.

Attempting to increase output and improve living standards, many countries to our south have undertaken specific programs of economic development. While investment continues to be made in Latin America by people and firms in the United States and Europe, the republics have undertaken to direct the development of their economies by establishing various agencies and giving them broad powers of economic planning. In

Mexico, for example, the Federal Industrial Development Commission was formed on June 1, 1944, on the basis of previously existing commissions. The development commission (Instituto de Fomento) in Colombia has been operative since the 1930's. In 1946 Argentina provided for the drafting of a five-year plan and turned over broad economic powers to the central bank. Brazil, Chile, Peru and Bolivia are other countries which have made provision for the establishment and operation of similar governmental or quasi-governmental agencies.

Notwithstanding active governmental participation in programs for economic development, these programs have met so far with only limited success. Each country has sought to step up the rate of progress, particularly since the end of the war, when machines and other capital equipment once more became obtainable from the United States and Europe. The industries already erected and those contemplated, however, face serious difficulties in their future growth. The problems obstructing their development are many, and in this paper I hope to discuss briefly some of them, although a satisfactory analysis can hardly be attempted in so short a space. Generalizations, furthermore, on possible solutions of these problems are impossible, and only by detailed study of the individual country concerned can suggestions be made that would apply to that particular area. The following discussion, then, can do little more than highlight the economic problems which our Latin American neighbors face in their economic development.

Without implying that the following order indicates the degree of gravity of the problem in economic development of Latin America, we might list (1) the development of transportation facilities, (2) the provision of adequate power and fuel to meet industrial development requirements, (3) the problem of financing, (4) the problem of population and immigration, (5) the need for improvements of education, (6) the elimination or reduction of political instability, and (7) the arrest of the postwar inflationary trend. It may be noted furthermore that these problems are closely interwoven. In fact it is virtually impossible to separate the economic from the social and political problems in Latin America.

For the industrial growth of Latin America the development of adequate transportation facilities and of power and fuel is fundamental. With respect to the former, the construction of railroads and of highways has probably proceeded farther in those countries which have enjoyed the higher degree of industrialization. The air traveler in Brazil can note the extensive network of airlines operating and at the same time observe the almost complete lack of ground transportation facilities so important to heavy industry. Except for a narrow coastal belt, Brazil is virtually undeveloped, and the settlement of large areas will undoubtedly await the construction of such facilities. The long range of mountains in eastern Brazil has constituted a serious barrier to the westward development of the country, and continues to make very costly the construction of transportation lines into the interior. The countries in western South America similarly face the difficult task of road and railroad construction through the high and rugged Andean ranges. In most of Central America and parts of South America the expansion of land transportation is hindered by a combination of mountains and jungles. Although air transportation has had a remarkable growth, particularly in Colombia and Brazil, it is still unable to compete with railroad and truck transportation in serving the day-to-day needs of industry and agriculture. Various nations to the South are at present tackling this problem, and both railroad and highway construction are going forward in Brazil, Bolivia, and elsewhere. The heavy financing costs and other problems make progress slow and retard the exploitation of resources of the area. Shortages of coal, oil, and gas and failure to develop the hydro-electric power potential impose another serious obstacle to the growth of industry. The discovery of oil in southern Chile and Argentina within the last few years promises to make these nations less dependent upon outside supplies. Likewise, Bolivia is attempting to expand its production of crude oil and its refinery capacity, so as to become self-sufficient, and Brazil is undertaking exploration and development of its oil industry. Only Venezuela. Colombia and Mexico can be considered as being self-sufficient in liquid fuel resources. The expansion of steam generation of electric power to meet the growing demand can be undertaken cheaply only if good domestic fuel deposits can be found and exploited. The development of hydro-electric resources would require heavy investment in generating plants and in transmission lines. The falls of the Guaira and Iguassu Rivers in Brazil on the Argentine and Paraguay boundaries have high electric potential, but they are located several hundred miles from any important industrial consuming areas. The Chilean government is perhaps making the most extensive effort of the various countries to the south in the development of their hydro-electric possibilities. Such construction brings to the fore, however, the problem of financing, which will be discussed at some length later in this paper.

Before considering the need of capital in Latin America, it is fitting to indicate the problems which impede investment in that region and the introduction of machinery and other tools of production. Acting as a brake on industrial growth is the limitation of the market in which the products of Latin-American industry can be sold, particularly the narrowness of the home market. Brazil, with an expanse greater than that of continental United States, has a population only one third that of our own. The population in the entire hemisphere south of us falls short of that of the United States. Even more important to the size of the markets is the small purchasing power of the masses. For the economic development of the region immigration is needed, and Brazil and some other nations have admitted considerable numbers of Europeans as immigrants. The general tendency, however, has been for the newcomers to settle in the already populated areas. Italians admitted to Argenina as agriculturists have frequently filtered back into the cities and towns to become merchants. Little serious effort has been made by the governments to settle the immigrants in the sparsely populated regions. Not much progress can be made in that direction without subsidizing the new settlers and without breaking up in some instances the large landholdings of a few individuals and firms in such areas as the state of Matto Grosso in Brazil, northern Paraguay, and northern, western and southern Argentina. In addition to agriculturists who are willing to face frontier conditions, most of these countries have a great need for technicians. In the last twelve years many skilled workers have come to Latin America from Spain and Central Europe, but the number falls far short still of that required for an effective industrial establishment.

Much of this need for skilled personnel can be satisfied only through the establishment of broader vocational training programs and by the expansion of general educational facilities. The need for better educational programs is particularly marked outside the metropolitan areas of the larger countries and throughout most of the smaller nations. The problem of education goes beyond merely teaching the worker how to handle American and European machinery and involves making him do what he has already been taught must be done. The maintenance of a highly mechanized economy requires a high degree of discipline of the workers. Of the two problems in the development economically of Latin America, that of educating the worker and that of inculcating in him the necessary discipline in the proper use of and care for machines, the latter conceivably can be the much greater problem.

In the development of transportation facilities throughout the various countries in Latin America and in the mechanization of agriculture, the introduction of improved techniques and the industrialization of the area, a major difficulty is that of financing. This problem in turn is closely bound up with the foreign trade of the region, with the political instability so generally prevalent, and with the problem of education already mentioned. There is little industrial equipment and agricultural machinery, even little in the nature of simpler agricultural implements, that is available to those nations out of their own production. The necessity for importing these requirements of their developmental programs and the need at the same time to import a large part of their requirements of consumer goods and to continue servicing their foreign debts have weighed heavily on the balance of payments of most of these countries. During the war their balance-of-payments problem was made much easier by the large volume of exports commanding high war-time prices and their inability to obtain the customary volume of imports, with a consequent accumulation of large dollar and sterling reserves. Two consequences of importance to their future development may be noted in connection with the growth of these foreign balances between 1940 and 1945. First, the accumulation of these assets in New York and London produced strong inflationary pressures in most of the Latin-American countries. As the central banks or foreign exchange authorities bought dollar and sterling drafts from exporters, they paid for these acquisitions in local currency. The outcome of this practice was a rapid expansion in the monetary circulation which accentuated the inflationary pressures resulting from the unusual economic activity and the high money incomes earned in producing the goods needed by the Allies in their war effort. With imports severely curtailed by the export controls of the United States, Britain, and other warring Allies, formerly important sources of supply, the Latin-American states witnessed a two-edged inflationary pressure in the form of higher money incomes and fewer goods on which to spend those incomes.

Without effective systems of price control, the Latin-American states generally experienced a greater and more rapid rise in their price indices than the United States, Canada or England. Whereas our wholesale price index rose about one third between 1938 and 1945, wholesale prices in Mexico nearly doubled. In Brazil wholesale prices more than doubled between 1940 and 1945, and the index in Colombia by the end of the war had risen to more than twice the 1942 level. Cost-of-living indices, where available, also tended to rise much farther during the war period than the index of our own Bureau of Labor Statistics. Since the end of hostilities, the upward movement has been even more pronounced.

The strong inflationary pressures in Latin America appear to be reaching their end in some areas, for example, in Brazil. As their prices have climbed much higher than the prices of products imported and since much of their production for export is inelastic, it seems likely that these countries face a correspondingly greater decline in the prices of their foodstuffs and raw materials in the coming months. Early in 1949 the price of Dominican cacao, for example, was only about 25 per cent of the quotations prevailing a year earlier. In the face of large exportable surpluses of wheat from the United States and Canada and of increased agricultural production in Europe, Argentina will no longer be in a position to exact the high prices of the last two or three years for its exports. The recent price decline of vegetable oils in the United States portends a similar fall in the prices of these products exported by Brazil, Argentina and other Latin-American states. Likewise, the drop in the wholesale prices of nonferrous metals in the United States will be reflected in a similar fall in the quotations of copper and other metals produced in Latin America. A consequence, then, of the greater inflation in the nations to our south will probably be a more serious fall in prices. It is possible, of course, that in certain countries domestic events will continue to exercise an overriding inflationary influence. Failing an extensive readjustment in their price structure, however, these nations will encounter even more grave difficulties than their present ones in maintaining their existing exchange rates.

The rapid increase in American production beginning in early 1946 and the prompt relaxation of export controls quickly permitted a flow of goods to that area in such volume that payment for them could be effected only by drawing heavily upon accumulated dollar balances. Colombia, whose gold and foreign-exchange reserves increased from 110 million pesos in 1942 to 309 million in 1945, suffered a fall in these reserves to 217 million at the end of 1947 and to 167 million by November 1948. Nicaragua's dollar reserves are now reported as exhausted. Argentina found it necessary in the past winter to suspend all payments in dollars for a period of about one month. In fact, with few exceptions, the Latin-American republics considered it necessary to impose stringent restrictions on imports of American goods. Despite these measures to balance their international accounts, several countries, notably Mexico, Colombia, Argentina and Uruguay have allowed some depreciation of their currency during the past year. The future, moreover, does not promise much respite for these nations in their international payment difficulties. Since the prices of their raw materials and foodstuffs will probably drop farther than the prices of their manufactured imports, we can look for the wartime improvement in the Latin-American terms of trade to reverse itself. As the prices they receive go down relative to the prices they pay, the difficulties of maintaining the dollar value of their currencies will be augmented.

Having lost a large part of their gold and dollar reserves, our Latin-American neighbors can finance new purchases of industrial and agricultural equipment for their economic development and maintain the rate of progress of the last ten years only if the value of their exports remains high, or if the debit items decline, or if they will accept investment of foreign capital in their areas. To a limited extent, they would benefit from the establishment of convertibility for European currencies. The countries of the River Plate region normally have a favorable trade balance with European nations, and most of the Brazilian favorable balance of 40 million dollars in 1948 was in non-convertible currencies. This problem will largely disappear as European industrial capacity is restored and European exporters again supply an important part of the requirements of the Latin-American area for machinery, but the re-establishment of convertibility would permit the acquisition of the required equipment more easily in the cheapest markets.

The continuation of Latin-American economic development will be promoted, furthermore, by additional investments of foreign capital. Political instability, however, and the opposition of political regimes to new foreign investment may create an atmosphere not inviting to foreign investors and by doing so retard their economic growth. When investment is sought, care must be exercised in the use of the funds to assure their productivity. The new capital expenditures must yield, moreover, not merely greater output per worker but increased exports (or decreased imports) providing greater supplies of foreign exchange for the service of foreign debts and the payment of reasonable profits to parent corporations abroad. In conclusion, it may be noted that the United States did not develop as an important industrial nation in a decade or even a generation. It is unreasonable to expect that the Latin-American states can effect their economic growth in a shorter period of time.

To summarize, the economic development of Latin America faces many complex problems, varying in nature and degree among the different nations. The utilization of sparsely settled lands awaits the development of better transportation facilities for carrying the products to market and for bringing in the necessary supplies. Greater amounts of cheap power, fuel and water must be made available for the development of industry. Immigration must proceed at a faster pace than in recent decades, and in some cases land reforms must be accomplished before any large amount of immigration can be absorbed within the counties. Educational programs of both technical and general character must be greatly expanded, and a higher degree of political stability achieved. Finally, ways must be found to finance the acquisition of capital equipment so needed to raise the productivity of the area. The most rapid and the greatest measure of progress can be achieved by these nations through economic cooperation with the rest of the world and the avoidance of a recurrence of the intense economic nationalism that developed in the 1930's.

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ATMOSPHERIC ELECTRICITY

W. F. Helwig
University of Texas

During eighteen years in West Texas, the writer has been interested in atmospheric electricity and has had an opportunity to carry out experimental work in this field. Most of the work was done in connection with a research program at Texas Technological College and was essentially a study of electrostatic effects under conditions of low humidity.

The most obvious phenomena originating from "natural charges" are lightning strokes, which are accumulations on a grand scale, while the common sand storm charges which, although much smaller in potential and charge-content, are quite annoying in West Texas and interfere with cotton processing.

Although electrical charge formation in nature is as old as the earth itself, little progress was made in explaining these effects until the discovery of the electron, and only during the past twenty years sufficient quantitative data have been collected by numerous experimenters in various parts of the world to permit a formulation of an acceptable general theory. C. T. R. Wilson (1929) and Simpson and Scrase (1937, 1941) published some original data on thunderstorms and arrived at a theory of charge formation. A modification of this theory by Humphreys (1939) appears to agree in general with the conclusions of other observers.

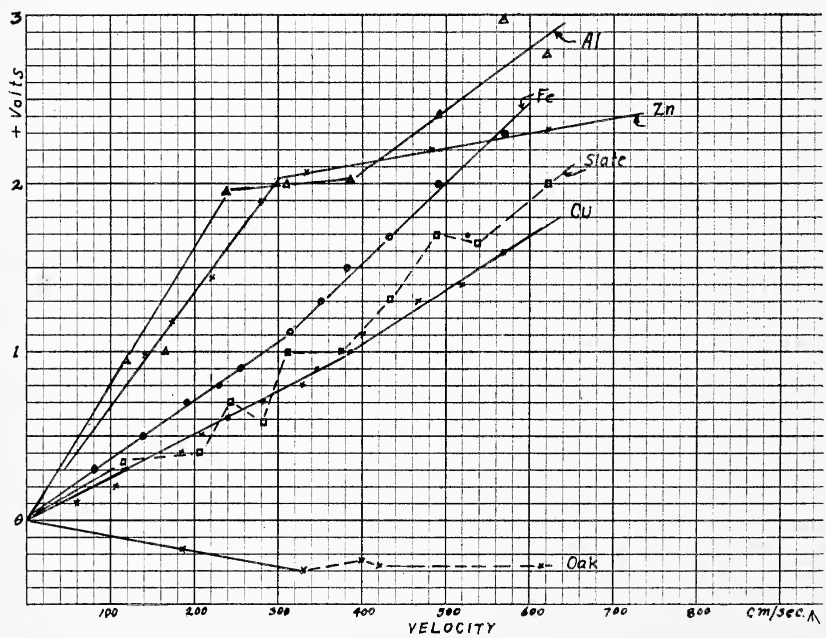
Briefly it is this: Wind approaching a thunder cloud is deflected upwards at a velocity too great to permit the fall of rain drops in its path. The drops are broken up by the jet of air, the spray particles becoming negatively charged with respect to air. As the wind travels higher into the cloud, its velocity decreases and its charge is given up to the vapor particles high up in the cloud formation. Between the upper and the lower portions of the rain cloud, observation balloons have detected a region of subzero temperatures, containing ice crystals, which serves as an insulating barrier between the upper (positive) and lower (negative) portions of the cloud. This distribution explains also the potential gradients along the earth in the path of an approaching storm cloud. This gradient is positive in advance of the cloud, negative directly under it and again positive beyond the trailing tip.

Although under fair weather conditions a gradient of 30 kilovolts per centimeter is required to cause ionization in air, measured values during thunder storms have indicated that 10 kilovolts per centimeter are sufficient to cause break-down within a cloud formation and this is thus the critical value which initiates the lightning stroke. The final path taken is governed by the geometry of the electrostatic field.

Concentration of the field above tall structures produces leader strokes from the structure, whereas on level ground the leader appears at a cloud tip. Once ionization starts, the length of path shortens, finally resulting in an arc. After the arc is established a low potential can maintain a flow of current and redistribution charges within the cloud formation may permit several strokes between the same points in rapid succession. In order to form some idea of the magnitude involved, a table with reference sources is given below.

Maximum current	160,000 amperes	W.T.D. (1944)
Maximum charge	160 coulombs	K.B.McE. (1941)
Maximum voltage	5,000,000 volts	R.P.-J.J.T. (1931)
Maximum energy (est)	250 kwh.	B.E.&A.I. (1941)
Wave front	143 kv per micro-sec.	J.H.C.-E.B. (1944)
Velocity of initial streamer 1.5 x 10^7 cm/sec.		
Time to ½% of initial current	200 micro-sec.	C.F.W.-E.B. (1939)

The writer's experiments in the field of "natural charges" were confined to laboratory measurements with frictional apparatus (W.F.H., 1948). Readings of accumulated potentials as well as average electron flow were made employing a cotton friction disk mounted on a polystyrene disk.



Various materials were employed as frictional electrodes and rate of charge flow under different conditions of humidity and temperature was recorded. Conclusions from a large number of readings indicated that the release of electrons from materials depends to a great extent on the available outer-shell electrons in the atom. This theory appears to be substantiated also by an examination of Tribo-electric Series (Smithsonian Physical Tables). The table below gives a few of the materials listed and the numbers on the left are those used in the above reference. The electron affinity figures are also given as shown in this reference except the two starred, which were computed by the writer.

No.	Material	Electron Affinity	Contact Potential	Outer Shell Electrons
14	Al	3.06	0.99	3
	Zn	3.46	0.59	2
17	Cotton	3.8*	0.25*	
20	Fe	3.86	0.19	2
25	Slate	3.9*	0.17*	L
28	Cu	4.00	0.05	1
32	Ag	4.05	0.00 *Base*	1

Readings of frictional effects taken by the writer can be shown best on a graph. For reasonable comparison, all readings had to be taken under the same conditions of humidity although normal variations in temperature showed little influence on the results. Aluminum, with three outer shell electrons, appears to give three distinct slopes in the velocity range covered, while both zinc and iron show two. Copper, with one electron, has practically a constant slope over the range, and all seem to converge to the same value around 700 to 800 centimeters per second. Within this range no "saturation effect" was observed and the transfer of charges was limited only by the available speed of the motor. Employing a disk eight centimeters in diameter, potential differences of 10,000 volts were read on the electrostatic voltmeter and estimates of 60,000 were reached with a series condenser. The line for slate, a composite material, shows the expected irregularity for non-homogeneous substance.

Applying the results of these studies to lightning phenomena we find: air, being chiefly nitrogen, should become positively charged when flowing in a region of water droplets. As the air flows upward it passes thru the icy region which is highly non-conductive, absorbing little of the positive charge carried. Thus most of this is carried to the upper part of the cloud. The physical separation of the charges by the wind energy produces the high potentials encountered in the cloud formation.

Although the writer has not had an opportunity to experiment with air streams, data obtained from frictional effects on material surfaces indicate that it is possible to obtain a transfer of about 10^9 electrons per square centimeter of contact surface. The total charge would depend on the velocity of surface transfer and up to at least seven meters per second shows a continuous increase. Some electrification of highly insulating materials was observed but these charges could be measured only by means of very sensitive instruments.

Dust storm charges are somewhat similar to lightning with this difference: the dust particles are sufficiently unlike to prevent any large accumulations of like charges from appearing in any one region. Although dust clouds of considerable magnitude affected by winds of high velocity have been encountered, the charges are subject to a random distribution and the low humidity prevailing requires a high potential gradient to produce ionization. Readings taken on about a 50 foot line some 25 feet above ground gave no indication of a predominant polarity. Rather, the dust particles discharged at a rapid rate with an occasional heavy discharge of one polarity and then another. Heavy charges would break down gaps of one-quarter to one-half inch and have been known to cause flash-over on high voltage transmission lines.

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NATURAL SCIENCES IN THE EMERGING CURRICULUM

G. P. Parker

Education and Psychology Department
The Agricultural and Mechanical College of Texas

The American public school and its curriculum are organized and controlled by society, but they function mainly for the purpose of integrating pupils as adjusted members of society. The continuation of this institution can be justified only by the service rendered to the democratic social order in which it must remain.

Democratic society by no means depends completely on the school system for the entire task of educating the oncoming generation. Such agencies as the home, the Church, the movies, the radio, television, the newspaper or magazine, the street, the playground, and the shop have very significant roles to play in the total educational process affecting the youth. The school system, however, is the institutionalized agency formally commissioned by society to perform the chief and most systematic educational service. The school, therefore, has the responsibility not only of instruction in the fundamentals; but of giving a balanced training and in some cases of providing education which definitely counteracts the effects of anti-social education.

As society continues to emerge from one generation into that of another, it becomes necessary for the school to emerge with it and to revise its curriculum to meet the needs of the present generation. Too often, the curriculum tenaciously retains traditionally established subjects taught by antiquated methods preparing pupils for a society of past generations.

Teachers most often are inclined to teach by methods with which they are best acquainted, and parents may demand that their children have the same kind of education that they themselves received when they attended school. Traditional subjects and methods have a prestige which makes it difficult to displace them or even to modify.

According to a recent report published by the Federal Security Agency, Office of Education, our high schools do not make sense for sixty per cent of our pupils. The nation's high schools must revise their courses completely to meet the needs of youth today.

A recent survey made for the U. S. Office of Education shows that 550 out of every 1,000 pupils withdraw before graduating from high school; the reason is that they fail to find the curriculum interesting, satisfying, and challenging. Most pupils feel that the curriculum offered is highly abstract and has little functional value. Citizenship training was found to be the weakest link in our educational program, and required courses too frequently are little more than exercises in memory without stress on interpretation and relationship to the contemporary society. Too few courses are functional in helping youth to fill his place in society. College preparatory curricula are dominant even in centers where very few students go to college.

The fore-mentioned report recommended that the pupil be taught in school to acquire salable skills and an intelligent understanding of economic life. High school should also make him familiar with the contributions of science, cultivate in him an appreciation of art, literature, music, nature, and develop his ability in the various areas of communication—reading, writing, listening, and speaking. He should learn to purchase, to use goods and services wisely, and to have respect for human personality, so that he will exhibit a high degree of tolerance, cooperation, and good will.

If the natural sciences are to take their places in the emerging curriculum, it will become necessary to reorganize subject matter content to meet the needs and interests of present day life. Science in most schools continues to follow the most traditional of all plans of curriculum organization—the Subject Matter Curriculum. Meanwhile five other types of curricula have developed. Some are relatively conservative departures from the Subject Matter Curriculum; others are revolutionary innovations indeed. What are these plans, and what do they offer the science curriculum?

1. *The subject matter curriculum.* This was the earliest curriculum of the European and American schools and continues as the predominant type. Many science specialists believe that their subject should be taught to transfer knowledge and are of the opinion that there should be no differentiation in subject matter requirements for individual pupils, those who go to college, or for those who do not.

Science subjects are arranged in order of supposedly progressing difficulty and are taught independently of each other. General science in the ninth grade, biology in the tenth, and chemistry and physics in the upper two years has been a sequence no ordinary science teacher has dared to violate.

2. *The correlated curriculum.* The first and, perhaps, the most conservative attempt to revise the curriculum has been that which gave a vote of confidence to the subject and departmental organization by establishing some common avenues to connect one subject field to another.

The English teacher for decades has been wanting teachers in other departments to help assume the responsibility for language proficiency. This has come closer to being a joint responsibility as correlation has become more popular. However, the natural sciences have been reluctant to attempt correlation except in a few instances. For example, chemistry and physics parallel the study of atoms, electricity, gases, heat, and pressure.

3. *The fused curriculum.* The second step away from the subject curriculum is fusion. The fused course replaces a number of subjects previously offered in either one or a number of different subject fields and draws heavily upon the replaced subject matter for content.

Fusion in the high school sciences saw general science orientate the pupil into both biological and physical sciences, and botany and zoology into biology. As indicated in these examples, fusion has been in the past almost exclusively the combination of courses within the same field. The fused course, as spoken of in the most progressive sense, refers to the course that replaces a number of subjects formerly taught in unrelated departments. In a great number of instances social studies, natural sciences, and art have been and can further be fused into one course.

4. *The broad-fields curriculum.* The broad-fields curriculum represents a definite reaction to the great multiplicity of separate subjects that were looked upon a few years ago as the answer to individual needs and interests. It indicated setting out a portion of the curriculum as essential for all and then arranging this common material into a few broad courses. For instance, assume that the three areas of the instructional program are to be:

a. Man's social relations
b. Man's relations with the universe
c. General arts

A radical departure from the subject curriculum might consider man's social relations from a unit approach, beginning in the first grade with the individual's relation with his home and leading to the study of world problems in the senior high school. The second area—man's relationship with the universe—would not retain isolated subjects in science but would start in the first grade and make its approach through the individual's relationship to the world of science. It would be closely related to the first area and would treat the use and conservation of human as well as natural resources.

5. *The core curriculum.* The provision of a common body of growth

experiences, usually spoken of as the core curriculum, is gaining popularity as a fundamental step in curriculum reorganization.

The core curriculum presupposes certain specific types of learning experiences as basic for all pupils going through the school but does not necessarily mean a common fixed body of content for all. It might be said that the core idea endorses a broad area of experiences rather than the specific experiences within that area, and generally refers to one broad-field which is set out as superior to any other broad-field and operates as a center around which the other broad-fields revolve. Numerous broad-fields have been proposed as the core around which all of the other fields should operate. On frequency of occurrence the social studies rank first, science studies second, and reading third. Obviously, social and science studies represent content areas. Little attempt has been made to champion those fields which represent primarily skills and appreciation areas.

6. *The experience curriculum.* The experience curriculum is the one type which definitely rejects the subject matter approach. It is more difficult to describe than any other type due to the fact that promoting the best all-around growth of the child in a continuously changing learning situation is one of its fundamental concepts. This makes for less agreement among its advocates in both theory and practice than that found among proponents of other types of curriculum in which consideration is given more to the total growth of the learner and to fixed-in-advance learning situations.

In the experience curriculum the selection, development, and direction of the experience are a cooperative undertaking in which pupils and teachers work together under teacher-guidance. The experience is selected on the spot by pupils and teachers who compose the particular learning group, and it should be designed to serve the needs of all pupils regardless of interest and abilities. Possibly the greatest advocate of this type of curriculum would be Einstein.

Science in the emerging curriculum as revealed by the President's Scientific Research Board shows that instead of a twelve-year science program, beginning in Grade One, relatively few children receive any organized science instruction until Grade Seven. In the earlier grades science teaching is in many places incidental. Sometimes it appears as part of the reading program and sometimes as the lesser adjunct in a social studies unit. Well trained elementary school teachers of science are few. Courses of study and textbooks show the kind of wide variation which is characteristic of an early stage of development. Equipment is either non-existent or inadequate. Teaching procedures are not well designed. There is an almost total absence of concern about locating, stimulating, and providing guidance for children with potential talent in science. The only encouraging sign is a widespread and heightening interest in science.

The Board found in the secondary schools an overcrowded curriculum, in which science is hardly represented to a degree in keeping with the needs of our times. All available data indicate that the percentage of high school pupils enrolled in science courses has been declining. The typical pupil takes two science courses during four years of work, one in general science and one in biology. The contribution which physical science can make to his education is not recognized beyond the elementary concepts treated in general science. A small number take the course in chemistry or physics at the eleventh or twelfth grade level, but the courses seem to be poorly designed for purposes of general education and fail to serve the needs of the talented pupils of the group. Very little attention is paid to the experimental methods of science or to the development of scientific habits and attitudes. The secondary schools rarely offer training in science beyond the initial courses in biology, chemistry, or physics.

Data are available which show conclusively that the subject matter studied in the public school bears no relationship to success in college; but that scholastic aptitude, habits of work, intellectual maturity, competent use of the mother tongue, and sense of personal and social responsibility are factors of validity. Conclusions drawn from scientific studies eestablish beyond question that the public schools need not be controlled by the traditional content and procedures.

As evidence accumulates showing that the subject matter of the subject curriculum bears little relationship to success in college, and as organizations representing the welfare of youth increasingly demand freedom from college domination, the public schools should be free to minister to the needs of American youth. If science is to find its place in the emerging curriculum, it will necessitate a complete reorganization of the science program. In the area of science this will mean more functional programs. The present specialized chemistry and physics courses will be replaced by generalized science courses stressing the practical phases which are functional in daily living.

In view of the fact that only 20 per cent of the pupils who graduate from the high school enter college and 80 per cent will receive no further general education, it is evident that the general science and biology offered are inadequate as a preparation for living in the highly scientific environment of today. Chemistry and physics should be fused into a single course so as to permit a broadened science program including additional study in elementary geology, meteorology, and a broadened and functional study of health and consumer science. According to such a plan science will be considered a core throughout the twelve grades of the public school system, and learning experiences will be adapted to the maturity and background of the pupils. In a well planned and coordinated science program throughout the twelve grades, the average graduate of our high schools should possess functional science knowledge equal to that of students who have completed the junior college at the present time. By the end of the sixth grade pupils can achieve growth in science equivalent to that possessed by the average ninth grade pupil after spending one year studying general science as it is taught today. Considerable science knowledge and understanding can be economically taught at lower grade levels than is now the practice.

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A DEFINITION OF INTERNATIONAL EDUCATION

By Spencer Stoker
Professor of Education
Texas State College for Women

The term "international education" has become a commonly employed term and like most terms that have become popular usage, it has acquired a vagueness of meaning that permits too much loose thinking. It is not the purpose of this paper to set up a final and accurate definition of the term, but rather to describe the conditions out of which the term has evolved and to offer a tentative definition that may be acceptable.

It may be of assistance, by way of establishing background, to examine the meaning of the word nationality in its societal significance. As feudalism gave way to kingdoms in Western Europe, the migrations and fixings of the masses were greatly restricted. This resulted in developing homogenous people within the confines of each kingdom. The people, through blood relationships, looked alike. One was identified as belonging to this or that kingdom because of the color of one's hair, eyes, or skin. These marks of identity are what are called ethnic qualities.

With the passing of time the word *kingdom* acquired a new meaning and a new name. The new name was "nation." This meant that the ethnic unity that had developed within the kingdoms prevailed within each nation. One was a Frenchman because one looked like a Frenchman. The accident of one's birth fixed one's nationality. One was a subject, citizen, or national of whatever nation one's ethnic characteristics decreed. There was no choice, one was fixed.

With the coming of modern times and the elaboration of the means of communication, men began to find homes outside the borders of their ethnic home or nation. As new nations established themselves the practice of soliciting immigrants became common. Unhappy people of old countries or nations were permitted to seek new homes across the sea.

As the number and strength of modern nations increased, and as the democratic concept spread, the practice of accepting citizens, or nationals through the process of naturalization was more or less universally accepted by the governments of the nations. This type of citizenship or nationality may be identified as a political nationality. Man's ethnic qualities no longer determined his nationality. Now, in general, he was free to choose his nation or nationality. He could flee from oppression or he could seek the land of promise.

Under these conditions nationality became a matter of individual decision, a matter of the individual mind. Thus internationalism became food for thought for the masses, whereas it had been a matter of concern only to the government officials during the time that ethnic nationality had prevailed. When the individual mind could think of choices in the realm of internationalism it soon extended itself into the various realms of human interest; interest in religion, in social welfare, in economics, in war, in peace, in political opportunity, and in health, and education as these interests identified themselves with idiologies and practices in foreign nations. Here it is that international education strikes root in the speculation and fancies of thinking man. He compares, contrasts, criticizes, and evaluates within his ever expanding international frame of reference.

With citizenship becoming a choice of the adult mind, the frame of reference of man's speculation has been extended to include the world as a whole. The revelations coming from the study of the sciences and humanities are constantly enlarging man's frame of reference. As each individual's frame of reference is extended he seeks more and more to put himself into a position that synchronizes more satisfyingly with his enlarged perspective.

Through the interpretation of these tendencies with the concept of political nationality, a new emphasis upon the individual's relation to internationalism emerges. Through his national government (democratic government) the individual insists that everything be done to enhance the international emoluments which he may covet. Increasingly the individual visualizes his sovereign rights (life, liberty, and the pursuit of happiness) in terms of international relations.

In support of these concepts references may be made to the developments in international trade and communication, the growing interest in international travel and human relationships, and the establishment of centers of study and research in foreign countries. Special emphasis should be placed also upon the deliberate efforts of governments to direct their persuasive appeals directly to the populations of the world by way of the radio. These appeals are made to the individual, not necessarily to the national governments. Frequently, significant policies and decisions of nations are announced to the world of men before the traditional courtesy of giving them diplomatic considerations is observed.

Running parallel with the above considerations are the policies of national education systems. More and more each nation is accepting the philosophy that education is the nation's first line of defense against all enemies—man or microbe. So universal has this philosophy become that each nation is actively sensitive to the educational philosophy of each member of the family of nations. No longer is a nation free to educate its citizens independently. It must take into account the prevailing policies and practices of comparable nations everywhere. Not only the team-work that may be taught but the attitude of the individual mind must be carefully and constantly in review. A major concern of the nations of the world today is "What is each man thinking?"

Perhaps one of the most active laboratories of international education is the one afforded by the political minority groups of the people of the world. Since the first World War minority groups have been sources of growing anxiety to the responsible nations of the world. National political idiologies are constantly influencing directly, or indirectly, dissatisfied minorities. The Marshall plan is in operation largely because of the influence of these ideologies. Nationally and internationally propaganda of many sorts is being directed to individuals of the minority groups. Those types of propaganda which are of a democratic nature are constantly emphasizing the rights of the individual—the inalienable rights of man. The increasing heterogenity of ethnic characteristics is contributing to the waning differences between peoples of different racial backgrounds. Who is different from whom? Whose rights are different from the rights of others? More and more the individual is being supported in his emergence as the average international man.

Closely related to the minority groups in their influence upon the concept of international education are the groups of people designated as displaced persons. Many national governments are actively concerned with the disposition of the displaced person—the man without a country, yet the man who deserves one. International agreements are being made to restore to the displaced person the right of a national home which can mean the subordination of national sovereignty to the inalienable rights of the individual.

The Nurenberg and similar trials of World War II criminals are other examples illustrating the growing belief that the rights of man take precedence over the authority of the nation. In these trials the codes of international law were amended to include concepts dealing with the laws of humanity. It would then appear from the conduct of these trials that the rights of man have prevailed over the rights of nations.

Based upon this brief and sketchy empirical approach to the meaning of international education, it appears that the word "national" may be eliminated from the term "international education." If this were done and the word "individual" or "man" were substituted for it, the term would be "inter-individual education" or "itner-man education." Going one step further, any qualifying word might be eliminated, leaving only the word "education" which might be defined as that activity through which the mind reacts to its frame of reference, the world as a whole.

EFFECTS OF RADIATION UPON THE BLOOD

M. Jeanne Fairweather, R. N.
Incarnate Word College
Winner of First Prize
Collegiate Division, 1948

INTRODUCTION

Man is constantly in search of the secrets of life and death. For centuries he has sought to find or devise means to defeat the forces of disease and destruction. Although he has succeeded in finding the cause of many diseases, and the cure for some, his relentless search goes on. Among the newer treatments, and one which gives great promise as a means of combating numerous diseases, is the X-ray. At the present time, other types of radiations, especially the various forms of radioactive isotypes, are becoming more and more important, both in medicine and in everyday life. These radiations useful in treating many types of disease, also produce a number of harmful side effects, one of which is an alteration of the blood picture.

In spite of the hazard of blood damage as an undesirable side effect of radiation therapy, until recently few data were compiled on the changes to be expected from regular X-ray therapy. Interest in this field of research was stimulated by the work of Heineke (1903), who described the damage caused by X-ray in the hemopoietic (blood forming) organs, and that of Senn (1903) who discovered that X-ray produced beneficial effects in human leukemia. In recent years, numerous papers have appeared which treat of occupational exposure, therapeutic exposure, and the experimental exposure of laboratory animals.

A typical example of results due to occupational exposure is the case reported by Weill and Lacassagne (1924) of two chemists, who worked for years with radioactive substances without any protection. They died within five days of one another. The death of one was due to aplastic anemia and that of the other to myelogenous leukemia, both of which are diseases of the blood resulting from prolonged exposure to radiation. Dickie and Hemplemann (1948) published the results of their research upon persons exposed to ionizing radiation at atomic bomb plants. They reported an interesting change in the lymphocytes of exposed workers. The lymphocytes of these individuals showed a larger number of refractive neutral red bodies than those of unexposed subjects. The total leucocyte count of the exposed workers showed a significant decrease, but differential counts revealed no difference in the percentage of lymphocytes.

The reported results relative to the effects of radiation therapy on the blood of patients closely resemble those obtained by the experimental exposure of laboratory animals. The local treatment of tumors and cancer, for example, does not usually cause severe blood changes, such as result from large and total doses from irradiation of the entire body, or from the internal use of radioactive isotypes. In treating patients, it is found that high radiation dosage will reduce the cells of all types in the blood and change the plasma constituents. Wyman Richardson and Robbins (1948) reported that although the white blood count fell almost at once, the patients did not show a significant change in the red blood count and hemoglobin levels until a month or two after the termination of the treatment.

Every type of radiation change found in the human blood has also been produced in laboratory animals.

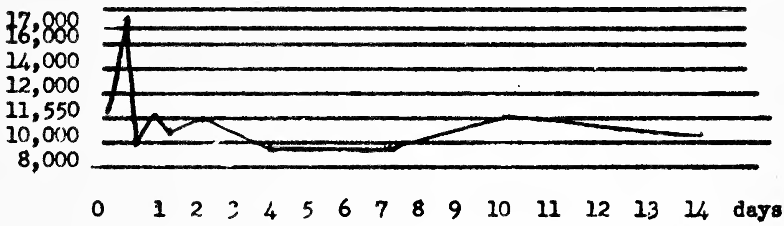
Nettleship (1944) studied blood changes in mice, whose entire body was exposed to low dosages of X-rays. According to his report, the average pre-experimental counts were as follows:

Leukocytes 11,550 Lymphocytes 6,800 Neutrophils 4,500

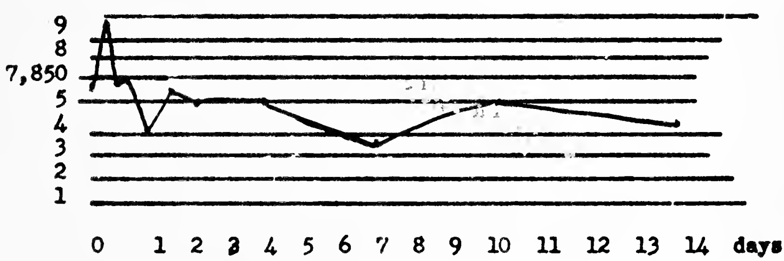
After exposure to X-rays, there was an abrupt rise in all three, followed by a sharp fall. The leukocytes reached their lowest level in 4 to 5 days. However, slight leukopenia due to lack of lymphocytes existed throughout the period of observation. Considerably more than two weeks was needed for the mouse to recover from the mild lymphopenia.

GRAPHS

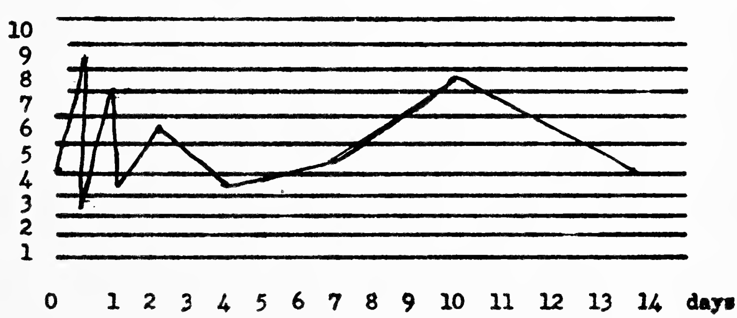
LEUKOCYTES



LYMPHOCYTES



NEUTROPHILS



As can be seen by the graphs, observations taken six hours after radiation conflicted with findings a day later. Therefore, it is extremely important that repeated determinations be made over short intervals of time.

The order of decreasing radio-activity of blood cells and their decreasing ability to recover from injury, was found to be as follows:

LYMPHOCYTES GRANULOCYTES ERYTHROCYTES

Warren (1948) observed that lymphopenia (decrease in lymphocytes) appeared in a few minutes after heavy X-ray, granulopenia (decrease in granulocytes) after a few hours, and erythropenia (decrease in erythrocytes) after several days or weeks.

It is important to note that these changes were in some cases progressive for weeks without further radiation.

Experiments to determine the effects of X-radiation on the blood of mice have been carried on in our school laboratory during the past six months. In all of the experiments, the animals were subjected to total body radiation. This was accomplished by placing six mice in a covered, light cardboard box which, because of its shallowness, prevented the mice from shielding one another. Radiation was delivered at the rate of 50 r per minute by using the following conditions: 200 k.v., 16 m.a., 50 cm. skin target distance, 0.5 mm. cu., 1 mm. al filters. The total dose of radiation in each case was 200 r which was applied in a single exposure. In the first series of experiments the blood studies consisted only of total leucocyte and differential counts. For all counts, tail blood was employed. Differential counts were made on air-dried blood films stained with Wright's stain. Pre-experimental control counts were made on each of the thirty-six mice used.

Experimental counts were performed on the day following irradiation and also on the 17th, 24th, 38th, and 55th days. In a second series of experiments, the blood studies included not only total leucocytes and differential counts, but also erythrocyte counts and hemoglobin determinations. Pre-experimental blood studies were made on all of the animals used. Experimental studies were made on the date following irradiation, again on the 6th day, and finally on the 13th day.

The total leucocyte counts showed considerable variations, but the average pre-experimental counts for the first series of experiments was 15,610 per cu. mm. There were slight variations in the differential counts but in general, there were about 83% lymphocytes and 17% neytrophils. On the day following irradiation, the total leucocyte count was 3,886 per cu. mm., while the differential count showed 72% lymphocytes and 28% neutrophils. In subsequent counts, both the total leucocyte and the differential counts gradually increased toward the normal.

The complete results for the second series of experiments are shown in the following table:

		DIFFERENTIAL			
	Total Leuco.	Lymph.	Neutro.	Erythrocyte	Hemoglobin
Pre-exp.	24,814	77	23	8,746,000	89%
Day after X-ray	8,580	60	40	9,740,000	87%
6th day "	4,956	57	42	7,800,000	85.5%
13th " "	7,168	73	27	7,658,000	85.4%

One can see from this table that, in general, the results obtained confirm those of other workers. All of the published records report a significant decrease in the total leucocyte count following radiation. In our results, as in those cited in the literature, the decrease in total leucocyte count was due chiefly to a destruction of lymphocytes. Richardson and Warren (1948) found that the erythrocyte counts and hemoglobin levels of human patients showed no significant change until a month or two following the termination of treatment. In our work, there was a slight increase in red cell count immediately after irradiation which was followed by a gradual but not very marked decrease a few days later. The hemoglobin level showed a slight decrease on the day following the treatment and continued to decrease gradually thereafter.

CONCLUSION

The experiments reported in this paper were preliminary to the work now being carried on in an attempt to overcome, by means of injections of beef spleen extract, some of the harmful side efferts of radiation therapy on the blood picture. It is hoped that we may have some favorable results to report at a later date.

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A PRELIMINARY LIST OF THE SIPHONAPTERA OF TEXAS*

Richard B. Eads and George C. Menzies
State Department of Health
Austin, Texas

Due to the growing realization of the importance of endemic typhus fever and the potential importance of sylvatic plague, attention has been recently focused upon the species of fleas present in Texas. In 1945 and 1946 a cooperative typhus investigation was made in Lavaca County, Texas, by the State Department of Health and the United States Public Health Service. Of the pools of fleas tested, 35 percent of the *Xenopsylla cheopsis*, 34 percent of the pooled *Leptopsylla segnis* and 14 percent of the *Echidnophaga gallinacea* were shown to contain typhus rickettsiae. During plague studies carried on in Texas by the same agencies in 1947, 1948 and 1949, positive pools of fleas were found in Gaines, Terry, Cochran and Yoakum Counties.

Unless otherwise stated, these records were made from 1945 through July, 1949, by personnel of the State Department of Health or the U. S.

Public Health Service assigned to Texas. Mr. V. I. Miles and Mr. Max Wilcomb of the U. S. Public Health Service made many valuable contributions.

Major Robert Traub, Army Medical Center, Washington, D. C. and Mr. Frank M. Prince, U. S. Public Health Service, San Francisco, Cal., have been generous with taxonomic assistance.

The family classification of Dr. Jordan (1948) is followed here as modified by Traub. However, the families and their genera are listed alphabetically.

Super-family CERATOPHYLLOIDEA

Family CERATOPHYLLIDAE

Dactylopsylla percernis Eads and Menzies, 1948.

Hosts: Pocket gophers, *Cratogeomys castanops, Geomys bursarius;* grasshopper mouse, *Onychomys leucogaster;* domestic rat, *Rattus norvegicus.* Recorded From: Armstrong, Gaines, Hartley, Lamb and Presidio Counties.

Diamanus montanus (Baker, 1895).

Hosts: Rock squirrel, *Citellus variegatus;* domestic rat, *Rattus norvegicus.* Recorded From: Kimble, El Paso, Menard, Presidio and Terrell Counties.

Foxella ignota Baker 1895.

Hosts: Grasshopper mouse, *Onychomys leucogaster* and pack rat, *Neotoma micropus.*
Recorded From: Dawson County.

Jellisonia bullisi (Augustson, 1944).

Host: Oak mouse, *Peromyscus pectoralis.*
Recorded From: Bexar County, 1944, by G. F. Auguston.

Jellisonia ironsi (Eads, 1946).

Host: Taylor mouse, *Baiomys taylori.*
Recorded From: Lavaca and Travis Counties.

Leptopsylla segnis (Schonherr, 1811).

Hosts: Domestic rats, *Rattus norvegicus* and *R. rattus;* domestic mouse, *Mus musculus.*
Recorded From: Bastrop, Bell, Bexar, Brown, Caldwell, Cameron, Colorado, Comal, Dallas, Galveston, Gonzales, Hardin, Harris, Henderson, Houston, Jasper, Jefferson, Karnes, Lampasas, Lavaca, Lee, Liberty, Travis, Victoria, Washington, Wharton and Williamson.

Monopsyllus exilis Jordan, 1937.

Hosts: Grasshopper mouse, *Onychomys leucogaster;* kangaroo rat, *Dipodomys ordii;* wood rat, *Neotoma micropus;* ground squirrels, *Citellus spilosoma, Citellus tridecemlineatus.*

* Based in part on a Dissertation presented by the senior author to the Agricultural and Mechanical College of Texas in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Recorded From: Andrews, Cochran, Dawson, Gaines, Garza, Lamb, Presidio, Terry and Yoakum Counties.

Monopsyllus wagneri Baker, 1904.

Host: Grasshopper mouse, *Onychomys leucogaster;* white-footed mouse, *Peromyscus leucopus.*
Recorded From: Dawson and Lamb Counties.

Nosopsyllus fasciatus (Bosc, 1801).

Hosts: Domestic rats, *Rattus norvegicus* and *R. rattus.*
Recorded From: Bexar, Bowie, Brown, Cameron, Comal, Dallas, Falls, Galveston, Grey, Harris, Henderson, Houston, Lavaca, Limestone, Lubbock, Madison, McLennan, Potter, Randal, Smith, Victoria, Washington, Webb and Williamson Counties.

Opisocrostis hirsutus (Baker, 1895).

Hosts: Prairie dog, *Cynomys ludovicianus;* grasshopper mouse, *Onychomys leucogaster;* cottontail, *Sylvilagus auduboni.*
Recorded From: Cochran, Dawson, Gaines, Hockley, Lubbock, Menard, Terry and Yoakum Counties.

Orchopeas howardii (Baker, 1895).

Hosts: Fox squirrel, *Sciurus niger;* raccoon, *Procyon lotor;* domestic dog, *Canis familiaris;* opossum, *Didelphis virginiana.*
Recorded From: Anderson, Brazos, Freestone, Kerr, Kimble, Lavaca, Medina, Menard, Uvalde and Williamson Counties.

Orchopeas leucopus (Baker, 1904).

Hosts: Pack rat nest, *Neotoma* sp. and *Peromyscus* sp.
Recorded From: Cameron and Howard Counties.

Orchopeas sexdentatus (Baker, 1904).

Hosts: Pack rats, *Neotoma micropus* and *N. albigula;* coyote, *Canis latrans; Mephitis mephitis;* ring-tailed cat, *Bassariscus astutus;* grasshopper mouse, *Onychomys leucogaster;* prairie dog, *Cynomys ludovicianus;* kangaroo rat, *Dipodomys ordii;* domestic rat, *Rattus norvegicus;* cottontail rabbit, *Sylvilagus auduboni.*
Recorded From: Andrews, Aransas, Bexar, Cochran, Dawson, Gaines, Garza, Howard, Hockley, Lamb, Lubbock, Lynn, Menard, Midland, Terry, Uvalde and Yoakum Counties.

Peromyscopsylla hesperomys (Baker, 1904).

Host: Grasshopper mouse, *Onychomys leucogaster.*
Recorded From: Dawson and Howard Counties.

Thrassis campestris Prince, 1944.

Hosts: Grasshopper mice, *Onychomys leucogaster;* pack rat, *Neotoma micropus;* kangaroo rat, *Dipodomys ordii;* cottontail rabbit, *Sylvilagus auduboni.*
Recorded From: Cochran, Gaines and Terry Counties.

Thrassis fotus (Jordan, 1925).

Hosts: Ground squirrels, *Citellus meximanus, C. spilosoma; C. tridecemlineatus*; wood rat, *Neotoma micropus;* grasshopper mouse, *Onychomys leucogaster;* kangaroo rat, *Dipodomys ordii;* cottontail rabbit, *Sylvilagus auduboni;* jack rabbit, *Lepus californicus;* domestic rat, *Rattus norvegicus;* pocket gopher, *Geomys bursarius;* skunk, *Mephitis mephitis.*

Recorded From: Andrews, Bexar, Cochran, Cottle, Dallam, Dawson, Gaines, Hockley, Lamb, Midland, Tom Green, Uvalde and Yoakum Counties.

Thrassis pansus (Jordan, 1925).

Hosts: F. M. Prince (1944) lists it from hosts *Onychomys, Peromyscus, Dipodomys, Neotoma* and *Cynomys.*

Recorded From: Brewster County.

Family HYSTRICHOPSYLLIDAE

Actenophthalmus sp.

Host: Grasshopper mouse, *Onychomys leucogaster.*

Recorded From: Cochran and Yoakum Counties. Mr. F. M. Prince is describing this species.

Anomiopsyllus hiemalis Eads and Menzies, 1948.

Hosts: Pack rat, *Neotoma micropus;* grasshopper mouse, *Onychomys leucogaster;* cottontail rabbit, *Sylvilagus auduboni;* prairie dog, *Cynomys ludovicianus;* cotton rat, *Sigmodon hispidus.*

Recorded From: Andrews, Cochran, Dawson, Gaines, Garza, Lamb, Midland, Terry and Yoakum Counties.

Megarthroglossus bisetis Jordan and Rothschild, 1915.

Host: *Peromyscus* sp.

Recorded From: In a personal communication Mr. F. M. Prince reports taking one female specimen from Donley County in 1947.

Meringis arachis (Jordan, 1929).

Hosts: Banner-tailed kangaroo rat, *Dipodomys spectabilis;* wood rats, *Neotoma micropus* and *Neotoma* sp.

Recorded From: El Paso and Gaines Counties.

Meringis bilsingi Eads and Menzies, 1949.

Hosts: Grasshopper mouse, *Onychomys leucogaster;* kangaroo rat, *Dipodomys ordii;* pack rat, *Neotoma micropus;* cottontail, *Sylvilagus auduboni.*

Recorded From: Cochran, Gaines, Terry and Yoakum Counties.

Meringis parkeri Jordan, 1937.

Hosts: Grasshopper mouse, *Onychomys leucogaster;* kangaroo rats, *Dipodomys ordii* and *D. spectabilis;* pack rat, *Neotoma micropus.*

Recorded From: Cochran, Dawson, Lamb and Terry Counties.

Family ISCHNOPSYLLIDAE

Myodopsylla collinsi Kohls, 1937.

Host: Cave bat, *Myotis velifer.*
Recorded From: Comal and Kinney Counties by Kohls and Jellison (1948).

Myodopsylla gentilis Jordan and Rothschild, 1941.

Host: *Myotis occultus.*
Recorded From: Medina County by G. F. Augustson (1939).

Sternopsylla texana (C. Fox, 1914).

Host: Mexican free-tailed bat, *Tadarida mexicana.*
Recorded From: Bexar, Brown, Comal, Lavaca, Medina, Pecos and Uvalde Counties.

Family RHOPALOPSYLLIDAE

Polygenis gwyni (C. Fox, 1914).

Hosts: Cotton rat, *Sigmodon hispidus;* domestic rat, *Rattus norvegicus;* opossum, *Didelphis virginiana;* domestic dog, *Canis familiaris;* spiny pocket mouse, *Liomys irroratus.*

Recorded From: Brewster, Brazos, Galveston, Harris and Jefferson Counties.

Rhopalopsyllus cacicus (Jordan and Rothschild, 1908).

(Syn. *R. coxi* Eads, 1946).

Hosts: Raccoon, *Procyon lotor;* skunk, *Mephitis mephitis;* opossum, *Didelphis virginiana;* armadillo, *Dasypus novemcinctus;* red fox, *Vulpes fulva;* red wolf, *Canis niger.*

Recorded From: Lavaca County.

Super-family PULICOIDEA

Family PULICIDAE

Cediopsylla simplex (Baker, 1895).

Hosts: Cottontail, *Sylvilagus floridanus;* jack rabbit, *Lepus californicus;* raccoon, *Procyon lotor;* fox, *Vulpes fulva* and *Urocyon cinereoargenteus.*

Recorded From: Brazos, Lavaca, Liberty, Menard and Navarro Counties.

Ctenocephalides felis (Bouche, 1835).

Hosts: Domestic cat, *Felis domestica;* domestic dog, *Canis familiaris;* opossum, *Didelphis virginiana;* raccoon, *Procyon lotor;* coyote, *Canis latrans;* red wolf, *Canis niger;* skunk, *Mephitis mephitis;* domestic rats, *Rattus rattus* and *R. norvegicus;* cow, *Bos taurus;* fox squirrel, *Sciurus niger.*

Recorded From: Probably present in all counties in the State; specimens have been examined from fifty counties scattered over Texas.

Echidnophaga gallinacea Westwood, 1875.

Hosts: Taken from a wide variety of avian and mammalian hosts.

Recorded From: Probably present in all counties in the State. Specimens examined from sixty-eight counties.

Hoplopsyllus affinis (Baker, 1904).

Hosts: Rabbits, *Lepus californicus, Sylvilagus aquaticus, S. auduboni;* bobcat, *Lynx rufus;* racoon, *Procyon lotor*; grey fox, *Urocyon cinereoargenteus;* domestic rat, *Rattus norvegicus;* ground squirrel, *Citelllus spilosoma;* prairie dog, *Cynomys ludovicianus;* kangaroo rat, *Dipodomys ordii;* wood rat, *Neotoma micropus;* grasshopper mouse, Onychomys *leucogaster;* coyote, *Canis latrans and* porcupine, *Erethizon epixanthum.*

Recorded From: Brazos, Cameron, Crockett, Dawson, Dickens, Donley, Duval, Gaines, Gray, Hockley, Hudspeth, Jeff Davis, Kleberg, Lamb, Lavaca, Liberty, Lubbock, Lynn, Menard, Pecos, Terrell, Terry, Tom Green, Uvalde, Williamson and Yoakum Counties.

Hoplopsyllus anomalus (Baker, 1904).

Host: *Citellus variegatus.*

Recorded From: Brewster and Presidio Counties.

Juxtapulex porcinus (Jordan and Rothschild, 1923).

Host: Javelina, *Tayassu angulatum.*

Recorded From: Probably occurs throughout the range of the javelina. Specimens examined only from Aransas, Nueces, Terrell and Uvalde Counties.

Pulex irritans Linnaeus, 1758.

Hosts: Dog, *Canis familiaris;* coyote, *Canis latrans;* red wolf, *Canis niger;* domestic rat, *Rattus norvegicus;* opossum, *Didelphis virginiana;* raccoon, *Procyon lotor;* striped skunk, *Mephitis mephitis;* grey fox, *Urocyan cinereoargenteus;* bobcat, *Lynx rufus;* badger, *Taxidea taxus;* prairie dog, *Cynomys ludovicianus;* ring-tailed cat, *Bassariscus astutus;* kangaroo rat, *Dipodomys ordii*; wood rat, *Neotoma micropus;* porcupine, *Erethizon epixanthum.*

Recorded From: Probably state-wide in distribution; specimens examined from sixty-eight Texas Counties.

Xenopsylla cheopis (Rothschild, 1903).

Hosts: Domestic rats, *Rattus rattus, R. norvegicus;* domestic mouse, *Mus musculus;* opossum, *Didelphis virginiana;* rabbit, *Lepus californicus; Sylvilagus* sp.

Recorded From: Sixty-one counties in every section of the State.

Family TUNGIDAE

Rhynchopsyllus pulex Haller, 1880.

Host: *Tadarida mexicana.*

Recorded From: Medina and Uvalde Counties, by Augustson and Ryan (1948).

Tunga penetrans (Linnaeus, 1758).

Ewing and Fox (1943) give a report of this species in Texas. Although it does not appear to be permanently established, it is included due to the ever present possibility of its introduction.

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THE RELATIONSHIP BETWEEN THE AGE AND RESPIRATORY ACTIVITY OF TOMATO ROOT TISSUE CULTURES

Joe Adamcik
Winner, 2nd Prize
Collegiate Division, 1948

Plant Research Institute and Clayton Foundation for Research
University of Texas, Austin

In this study root tissue of a genetically uniform strain of tomato was grown in White's solution supplemented with thiamin and pyridoxine and niacin. All eight possible combinations of the three vitamins were tried. Two or three tissue cultures with the same vitamin supplement were combined in a Warburg manometer vessel and covered with a composite solution made from the solutions from which they had been taken. In order to absorb carbon dioxide liberated during respiration, 0.2 ml. of 1.25% sodium hydroxide was used in the side arm of the vessel. The vessels were then attached to the manometers and placed in a constant temperature bath maintained at a temperature as near as possible to that of the culture room. For any particular experiment the temperature of this bath was constant to within ± 0.05° C. The vessels and manometers were shaken at the rate of 180 oscillations per minute and were allowed to equilibrate for twenty minutes after which the stopcocks were closed and readings of the oxygen uptake taken at five minute intervals for a period of seventy minutes.

The manometric constants were applied to obtain the number of cubic millimeters of oxygen absorbed. The root tissue was then dried to constant weight at 105° C and its dry weight determined. The number of cubic millimeters of oxygen absorbed per centigram dry weight of tissue were calculated. These results were graphed.

It was found in previous experiments that only those tissues which grew appreciably afforded a large enough sample to be easily measured by this method. Therefore, in the present series of respiration experiments, only those vitamin supplements which supported appreciable growth were considered. These were full vitamin supplement, thiamin + pyridoxine, and niacin + thiamin.

Figure 1 shows a typical series (Series 2) of tissue with full vitamin supplement in graphic form. It will be observed that respiration decreases with both age and increasing dry weight. This general trend is observed in other series and with other supplements as is shown by Table 1. This table shows the respiration observed in one hour's time, on the basis of dry weight. It can be seen that the respiration rate falls progressively with increasing age of the tissue.

As an aid in investigating this decline in respiration with age, Table 2 was prepared. This shows, for Series 2, the most rapid and least rapid respiration rates in mm^3/cg dry wt/hr. The ratio of $\frac{\text{most rapid respiration}}{\text{least rapid respiration}}$, calculated from these data, is also given. Similarly, the dry weight for the week of most rapid respiration in centigrams and the dry weight for the week of least rapid respiration is included. Another ratio which was obtained by dividing the latter by the former is also shown. The respiration ratio is indicative of the proportionate decrease in respiration, while the dry weight ratio is indicative of the proportionate increase in dry weight.

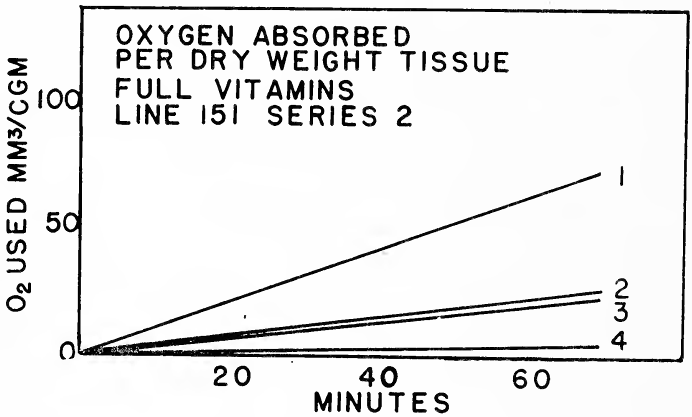

FIGURE 1

The respiration rates of tomato root tissue cultured on White's medium supplemented with thiamin, pyridoxine and niacin.

SERIES 1

VITAMIN SUPPLEMENT	mm³/cg dry wt/hr Week 1	2	3	4
1. Full vitamin (thiamin + pyridoxine + niacin)	43	36	23	17
4. Thiamin + pyridoxine	37	35	21	3
8. Niacin + thiamin	----	69	38	14

SERIES 2

	1	2	3	4
1. Full vitamin (thiamin + pyridoxine + niacin)	63	22	20.5	4
4. Thiamin + pyridoxine	83	32.5	34	10
8. Niacin + thiamin	----	51	13	11

SERIES 3

	1	2	3	4
1. Full vitamin (thiamin + pyridoxine + niacin)	61	64	47	27
4. Thiamin + pyridoxine	112	122	35	34
8. Niacin + thiamin	90	---	72	----

TABLE 2

The relationship of the most rapid and least rapid respiration rates to dry weight of tomato root tissue cultured on White's medium. Series 2.

Treatment	Most rapid respiration $mm^3/cg/hr$	Least rapid respiration $mm^3/cg/hr$	$\frac{\text{Most rapid respiration}}{\text{least rapid respiration}} = \frac{\text{column 2}}{\text{column 3}}$	Dry wt. in cg. at wk. of most rapid resp. rate	Dry wt. in cg. at wk. of least rapid resp. rate	$\frac{\text{Dry wt. least rapid resp.}}{\text{Dry wt. most rapid resp.}} = \frac{\text{column 6}}{\text{column 5}}$
1	2	3	4	5	6	
(1) Full vitamins	63	4	15.75	0.48	1.23	2.56
(4) Thiamin + pyridoxine	83	10	8.30	0.13	0.76	5.85
(8) Niacin + thiamin	51	11	4.64	0.40	0.78	1.95

TABLE 3

Summary table showing the ratio of $\frac{\text{most rapid respiration}}{\text{least rapid respiration}}$

and the ratio $\frac{\text{dry weight Wk of least rapid respiration}}{\text{dry weight Wk of most rapid respiration}}$

	Series 1		Series 2		Series 3	
Vitamin supplement	Resp. Ratio	Dry wt. Ratio	Resp. Ratio	Dry wt. Ratio	Resp. Ratio	Dry wt. Ratio
1. Full vitamin	2.53	3.92	15.75	2.56	2.37	1.23
4. Thiamin + pyridoxine	12.34	4.50	8.30	5.85	3.59	3.09
8. Niacin + thiamin	4.93	3.65	4.64	1.95	1.25	8.60

It is agreed that these figures are only approximations because no attempt was made to insure that only the young terminal portions were used as original explants. Portions of the tissues may actually have been considerably older when used as these explants. Elimination of this uncertainty will be discussed later.

Table 3 is a summary table containing only the two ratios mentioned above. It will be noticed that in seven out of the nine cases, the respiration decrease is larger than the dry weight increase. The total respiration of any particular culture decreased with increasing age and further, the respiration rate calculated on the basis of dry weight decreased at a faster rate than the dry weight increased. This behavior could result from: (1) all of the tissue not respiring as rapidly or (2) the total amount of actual respiring tissue being smaller or (3) a combination of these two.

A number of experiments have been suggested by this study. The above mentioned error due to the possibility that old tissue was used as the original explant could be eliminated by selection of only the terminal portions of the roots for the explants. If this is done, it will be certain that the actual age of the culture will be near the length of time it has been grown in the flask.

In addition, a useful study would be separate respiration measurements of the terminal and basal portions of the cultures. This would indicate whether the tips are respiring at the characteristic high rate of young tissue and whether or not the increase in non-respiring matter (dry weight) in the basal portions is sufficient to account for the whole of the decrease in respiration for the entire culture; in order words, whether the respiration decrease is centered almost wholly in the older parts of the culture, or whether the age of the parent tissue, perhaps by passing on poisonous by-products of growth, affects the younger tissue sufficiently to be a significant factor in the decline in respiration.

Additional experiments were performed on a related strain of tomato in which the basal centimeters, the terminal centimeters, and the intervening portions were separated and their respiratory rates determined. On the basis of a limited number of these experiments made on tissue with full vitamin supplement it was found that the terminal centimeter portions respire about twice as rapidly as either the basal centimeter portions or the intervening portions.

SUMMARY

Tomato root tissue was grown in White's solution containing various vitamin supplement combinations.

Respiratory measurements of these cultures were made by Warburg's direct method and the readings calculated on the basis of dry weight.

The respiration on the basis of dry weight decreased with age. The respiration on the basis of dry weight decreased more rapidly with age than the dry weight increased.

Further experiments with the purpose of investigating more fully this decline in respiration with age are suggested.

POISONOUS PLANT PROBELMS

Omer E. Sperry
Department of Range and Forestry
The Agricultural and Mechanical College of Texas

Of the more than sixty species of plants on the range lands of Texas, some twenty or thirty are of major importance in specific areas and localities during certain seasons. Our poisonous plants are, in the main, native plants which have increased in area and have become troublesome with overgrazing.

Bitterweed leads the list of killers since many head of sheep are lost each year from this plant. Bitterweed is an annual, frequents disturbed areas and grows rapidly when moisture is available. It is normally a winter annual but often persists most or all of the year. The greatest losses occur during the winter and spring following rain, when more palatable green forage is not available. Although 1948 was not considered a severe bitterweed year due to the dry weather throughout the infested area some ranchmen lost up to 50 percent of their animals by this weed. In every case investigated losses were due to lack of green feed or in some cases lack of any feed.

Most sheepmen realize that the only approach to the control of bitterweed poisoning is to first control the bitterweed by getting a good cover of grass. Rotational and deferred grazing, reduction of numbers, and in some instances smaller pastures and additional waterings are the chief management measures that must be followed. Chemical eradication, by 2, 4-D and perhaps other chemicals, is being widely used on bitterweed with varying degrees of success. If the eradication is a device to continue heavy stocking, the ranchman is still the loser. If the eradication is used to remove competition to give the grass a better chance, the use is of considerable merit. One school of ranchmen attempts to meet the situation of lack of range feed by supplementing hay and high protein feed. In a few cases a "medicated feed" has been used as a supplement. While feed probably lessens the death rate, it is by no means a cure to the problem. Complete deferment in severe bitterweed infested areas over periods of from three to five years has enabled grass to completely crowd this pest from a number of range areas and although a costly process, appears to be the only certain method to follow.

There are two species of senecio which have caused the death of numerous cattle in the Big Bend area this past year. Drought and continued heavy stocking have contributed to the losses. Here again the senecio seems to move into the background when sufficient range forage is available. As with bitterweed, 2, 4-D promises to be an important help in a management program.

Sachuiste furnishes much forage during the winter months but is very poisonous when flower buds and blooms are eaten. Some ranchmen eradicate the plant so as to have yearlong range; others remove stock during the flowering period.

Oak furnishes some forage but again oak bud poisoning is a serious problem. Stock cannot be run in oak areas during the early leafing period without considerable risk of loss.

There are three or four species of loco that present a serious problem, especially in the Big Bend Area. Mechanical or chemical eradication seems to be essential as an adjunct to more grass in the control of losses from "locoism."

High death losses are recorded on ranches which have alkali flats infested with rayless goldenrod. Some ranchmen are attempting eradication by "chopping" the plant out, while others fence off the danger areas. Chemical eradication seems to offer some relief on this species.

Jimmy fern, peavine, broomweed, yellowweed, milkweed, baileya, drymaria, coyotillo and a few others are also creating poisonous plant problems on our ranches.

EARLY SUMMER FOODS AND MOVEMENTS OF THE MULE DEER *(ODOCOILEUS HEMIONUS)* IN THE SIERRA VIEJA RANGE OF SOUTHWESTERN TEXAS

Alfred W. Anderson
Game, Fish and Oyster Commission
Rockport, Texas

INTRODUCTION

Food habits and local movements of the mule deer *(Odocoileus hemionus crooki)* were studied in the Sierra Vieja Mountains 11 miles west of Valentime, Presidio county, Texas, from June 4 to July 9, 1948.

Little is known of the foods taken by the mule deer in this region. Mearns (1907) and Bailey (1905) both reported some of the foods taken by the mule deer in Arizona and Texas. The Interstate Deer Herd Committee (1947) reported browse and grass percentages used by the mule deer of California.

The field work was done in a University of Texas field party under the direction of Dr. W. F. Blair. I am indebted to other members of the field party for observations that add to the knowledge of the local movements of the deer. All antlers and skeletons found on the C. E. Miller ranch were brought together and catalogued for the Texas Natural History Collection, Zoology Department, University of Texas. The locations at which these antlers and skeletons were found supplement my information about the local range of the deer.

This report concerns the food habits of the mule deer, the local movements and daily rhythm of activity, social behavior and water relations. Because so little is known about the foods of the mule deer in southwestern Texas the food habits were concentrated on in the field work.

FOODS

The foods were determined by observation of feeding deer with the aid of 8 x 30 field glasses and by collection and identification of the foods being taken. Feeding minutes is an expression of time while feeding on one species of plant. One feeding minute denotes one deer feeding one minute on one species of plant. The tabulation of feeding minutes in the field was difficult with large numbers of deer, so, where herds of twelve or more deer were sighted and observed, only the feeding minutes of twelve deer were recorded. The error in this method is smaller than if more than twelve deer were observed while feeding. The foods listed are believed to be accurate for the time and species used. It is evident that the foods here reported were spring and early summer foods, as this study was limited to the month of June and the first eight days of July. Work at other seasons may indicate different food habits at other seasons.

The mule deer took 13 foods in 1287 observed feeding minutes. Observation was made on 26 separate days. Two or more observations were made on four days. The foods taken with feeding minutes and percentages of the total time each was eaten are shown in Table I.

TABLE I

Foods taken by the mule deer *(Odocoileus hemionus crooki)* in the Sierra Vieja Region of Southwestern Texas from June 4 to July 8, 1948. Percentages of total foods taken with percentages of grazing and browsing.

Foods Taken	Feeding minutes	Percentage of total	
Agave lechuguilla	123	9.5	
Artemisia mexicana	2	0.2	
Ephedra trifurca *Ephedra antisyphilitica*	90	7.0	
Juglans rupestris	44	3.4	
Juniperus monosperma	18	1.4	87.0% browse
Lonicera arizonica	13	1.0	
Phoradendron coryae			
Phoradendron bolleanum	101	7.8	
Quercus emoryi	294	23.0	
Quercus grisea	101	7.8	
Rhus choriophylla *Rhus trilobata*	145	11.3	
Ungnadia speciosa	28	2.2	
Yucca carnerosana	160	12.4	
Bouteloua spp.	168	13.0	13.0% graze
Totals	1287	100.06	100.00

Emory's oak *(Quercus emoryi)* constituted 23.0% of the total foods taken and was the food used in greatest amounts. *Rhus choriophylla* and *Rhus trilobata,* two species of sumac which are closely associated with Emory's oak, comprised 11.3% of the total foods taken by the deer. Yucca *(Yucca carnerosana)* represented 12.4% of the total foods used. Lechuguilla *(Agave lechuguilla)* comprised 9.5% of the foods taken by the mule deer. Lechuguilla and yucca are both important foods in the browsing group. These plants were both found on the mesas, but the yucca alone was found on the flats. These two foods are probably more important than is indicated by my data, because much night, early morning and late evening feeding was done on the flats and mesas. The lechuguilla and some of the yucca showed evidence of browsing by deer. If accurate observation were possible during the late evening hours and moonlight night hours the percentages of lechuguilla and yucca might be raised.

Bailey (1905) reported "They eat the green stalks of the big century plants *(Agave wislizeni* and *applanata)* and pry open the cabbage-like caudex of the sotol *(Dasylirion texanum)* for its starchy and juicy center." In my own investigation I found no indication that sotol centers had been taken but there was evidence that the mule deer had taken the centers of lechuguilla and yaucca.

Gray oak *(Quercus grisea)* and mistletoe *(Phoradendron coryae* and *Phoradendron bolleanum)* each represented 7.8% of the foods taken.

Browse foods made up 87% of the diet of the mule deer while graze foods constituted only 13% of the total foods taken. Low annual rainfall is characteristic of the region and prevents abundant growth of most of the grasses; thus the deer are probably forced to take browse foods. The average rainfall on the C. E. Miller ranch from 1937 to 1944 was 14.69 inches. The average rainfall in the first five months during the years 1937 to 1944 was 2.64 inches. The rainfall for the first five months of 1947 totaled 3.18 inches. The rainfall for the first five months in 1948 in the area investigated totaled only 0.54 inches. The month of March was not reported but I am reasonably certain that no rain fell in that month. The rainfall in the first five months was, therefore, considerably deficient. Heavy rains on June 1 and June 2 totaled more than 1.75 inches, which noticeably increased the growth of grass.

The browse foods were important in all of the associations investigated. A fairly constant low percentage of grazing was shown in all of the associations where feeding was observed (Table II). The highest grazing percentage, 15.6%, was in the catclaw-grama association. The grazing percentage in the catclaw-tobosa was 12.3%. An average percentage for the minor miscellaneous associations was 12.0%.

TABLE II

Feeding minutes and grazing percentages of mule deer *(Odocoileus hemionus crooki)* in several econogical associations of the Sierra Vieja Region, from June 4 to July 8, 1948

Association	Recorded observations	Recorded minutes	Grazing percentages
Catclaw-grama	12	541	15.6
Lechuguilla-beargrass	6	139	12.7
Catclaw-tobosa	13	526	12.3
Misc. associations	4	81	12.0
Totals	35	1287	

Good evidence of the preference of the mule deer for browse at this time and place was obtained when two different herds of deer were observed feeding over a large alluvial fan at the mouth of Knox canyon, 1.1 miles south of the Miller ranch house. The percentage of grazing was only 9.4 even though there was a good stand of grama grass *(Bouteloua* spp.)

During this period Mexican walnut *(Juglans rupestris)* and yucca constituted the main portion of the diet. One other time gave good evidence for the low percentage of grazing. Eleven deer were observed as they moved through a catclaw-tobosa association. Three species of plants were taken as food. The food taken in greatest amount was jointfir *(Ephedra trifurca* and *Ephedra antisyphilitica)*, next was yucca, followed by grama grass. The grazing percentage of 16.5 was the highest observed in the entire study.

A much higher graze percentage was shown for the mule deer in California by the Interstate Deer Herd Committee (1947). In a five-month period of study they found a decrease in browsing from 61.3% in November to 33.6% in March.

ACTIVITY

The daily rhythm or activity is definite and is probably controlled mainly by temperature. As the warm hours of the morning approach the deer move from the mesas and the flats toward the canyons. This movement is slow and deliberate and provides additional time for feeding. As the temperature rises the deer move into the shade of the larger trees which give protection from the sun. The gray oak, Emory oak and cedar *(Juniperus monosperma)* were the trees most often selected by the mule deer, probably because the other large bushes offer less shade than these trees. The mule deer rest through the day in the shade and leave only when the temperature drops enough to permit comfortable feeding. Deer were seldom seen active in the middle of the day. Mearns (1907) said regarding the mule deer, "It usually feeds in the morning and evening, spending the hottest part of the day in the shade of a tree or rock." In my work, resting deer were observed between 9:30 a.m. and 4:30 p.m. As the deer left these resting points in the evening they spread over the mesas and flats for evening and night feeding. Deer were seen feeding during the moonlight nights of June up to 10:00 p.m. when observations were discontinued.

SOCIAL BEHAVIOR

The mule deer were definitely gregarious. They were seen in herds of up to 23 individuals. Groups of as few as two, three, and four deer sometimes fed together. If small groups were frightened they soon joined other deer to form a larger herd.

While feeding, the deer spread in a semi-fan-shaped formation. The young deer bring up the rear of the herd and appear to be more nervous while feeding than the older animals. When feeding on a large slope the deer move along several paths. The deer in a given trail usually feed on the foods taken by the leading deer.

The deer have a fright reaction that is characteristic. If frightened they join together as a tight group and run or lope in a single line. This was observed on the flats, mesas and in the canyons.

WATER

Surface or free water apparently is not required by the mule deer. Even with the shortage of green foods and the combination of high temperatures and low humidity the deer use little or no free water. In the total time of investigation no deer were seen to take water. We found many places in the canyons and on the mesas where standing water holes had deer tracks, but these tracks only passed the holes. No tracks of standing deer were found. According to Mearns (1907) "It is also apt to go to water in the evening or early morning, and, hunters say, on moonlight nights." In my own investigation during nine observations a total of 43 deer were seen to pass points with standing or surface water. At no time did the deer pause or stop to take water. Water for the diet is probably obtained in the foods such as yucca, lechuguilla and sumac. The hearts of both lechuguilla and yucca were used by the deer. Both of these have a high water content.

MORTALITY

Four deer skeletons were found. These skeletons with several shed antlers supplement my information about the possible areas of movement of the mule deer. The skeletons also provide possible evidence for the cause of death of some of the deer.

One buck skeleton was found on a rock slide, and from the number of fractured bones it may be safely assumed the deer was injured in a rock slide and died at the point of fall. There was fracture of the right femur, left tibia and left fibula. The vertebrae of the neck were not damaged, indicating no injury of the vertebrae by predators such as the mountain lion *(Felis concolor)*. The skeleton was not scattered. This was the skeleton of an eight point buck and the diameter of the antler one inch above the corona was 33 millimeters.

During one period of observation a buck was seen to fall on a rock slide with apparent damage to the right fore-foot. As the deer left the scene of the fall there was no use of this foot. This deer was trailed and seen again in about one hour, but had not, at that time, regained the use of the foot.

One skeleton of a doe was found in a clump of cedars in Z. H. Canyon. This skeleton was found in a well sheltered position, indicating that the deer possibly took shelter for protection during disease or injury. None of the bones was fractured, so it is possible that the deer died from disease or parasites.

One buck skeleton was found in the stream-bed association of Z. H. Canyon. The bones of this skeleton were scattered over an area of 150 square feet. The bones that were located were in bad condition, possibly indicating that they had been scattered by scavengers. The antlers of this deer had six points and had a diameter one inch above the corona of 30 millimeters.

One skeleton of a buck was found in sumac close to the top of a mesa. There were no points above the primary branches and, as one antler was broken, it was not possible to determine the number of points. The diameter of the antler one inch above the corona measured 36 millimeters. This skeleton was well hidden from sight and well protected from the sun and wind. The bones had no fractures and the vertebrae of the neck were in good condition. It seems possible that this deer took shelter during a period of disease and remained to die.

These skeletons indicate two possible causes of death. Actual investigation of diseased deer would give better indication of death rate due to disease and parasites, while observation of deer over a long period of time would probably give an indication of the death rate due to accidents.

SUMMARY

A survey of the foods used by the mule deer *(Odocoileus hemionus crooki)* was made in the Sierra Vieja region of southwestern Teaxs from June 4 to July 9, 1948. A total of 1287 feeding minutes was recorded, showing that 13 species of plants were being used by the mule deer. Emory's oak *(Quercus emoryi)* constituted 23% of the total foods and therefore was the most important food item in the diet of the mule deer in this area at the time of the study.

Browse foods constituted 87% of the total foods taken while graze foods made up only 13% of the diet of the mule deer.

Daily activity is probably controlled by temperature. A period of little or no activity is shown during the hot hours of the day.

Mule deer are gregarious during periods of feeding and moving. When frightened the deer group together and move from the area of danger.

Evidently, surface or free water is not needed by the Mexican mule deer. No deer were seen taking free water.

Disease and accidents both probably account for some natural deaths of the mule deer in the field.

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A PRELIMINARY REPORT ON THE FLORAL COMPOSITION OF A *SPHAGNUM* BOG IN ROBERTSON COUNTY*

Chester M. Rowell, Jr.
Department of Biology
The A & M College of Texas

There is a small area located approximately fifteen miles east of New Baden in Robertson County that is quite different from the surrounding country. It is an immature peat or *Sphagnum* bog, locally called "Black Boggy." Situated between two sandy hills, it is unique from most other valleys in the area by having a distinct flora and remaining moist even when the season is very dry.

There are several more bogs in the state, but this one is one of the youngest. Others are found in Anderson, Gonzales, and Lee Counties, as well as in Robertson County.

* The writer wishes to express his appreciation to The Texas Academy of Science for the research grant awarded him while working on this project.

To my knowledge all of the true peat bogs of Texas are found in the Carrizo sands. These sands constitute one of the lower units of the Claiborne group in the middle Eocene system. They form a diagonal strip across the state from the northeast to the southwest.

The bog proper is over three hundred yards long and has a maximum width of approximately three hundred feet. It is irregular in outline, but forms a long "C"-shaped curve and follows an east-west direction. Through the middle and with its origin immediately above the bog is a small stream. It apparently is fed only with the water that seeps out from the surrounding hills. There may be a small rise at the end of the valley that helps the area to retain some of its moisture.

At this time, there have been no samples taken to determine the stratification and depth of the bog. However, by probing in the more moist areas, a hard layer has been found at a depth of from two to three feet. This is probably an impervious clay stratum as is found in the Patschke Bog in Lee County. The soils in the whole area are very high in sand content, but in the bog proper there is a great deal of black organic material mixed in with the sand. There has not yet been enough accumulation of organic material to form any real peat. Present indications are that the major reasons for the floristic differences exhibited in the bog are the water content of the soil and the accumulated organic materials.

The flora of the bog area fits into three natural zones. The first consists of the typical forest of the oak-hickory association. These woods extend to the edge of the bog and penetrate it in places. The second zone consists for the most part of low shrubs, grasses, and several other herbaceous forms. The third zone is a tall shrub group in the center of the bog following the stream as it winds through. This zone is not typical of the other bogs observed and has questionable influence on the rest of the bog flora. There is a general drop from the woods edge to the stream totaling approximately seven feet. The slope is more gradual towards the woods, becoming rather abrupt at the stream's edge.

Zone one is typical of the oak-hickory association of the deciduous forest formation of central east Texas. The following are most abundant and may be considered the dominants:

Post Oak—*Quercus stellata* Wang.
Black Jack—*Quercus marylandica* Muench.
Sand Jack—*Quercus cinera* L.
Buckley's Hickory—*Carya buckleyi* Durand
Yaupon—*Illex vomitoria* Ait.

The following trees vary in occurrence, but are generally present:

Deciduous Holly—*Ilex decidua* Walt.
American Holly—*Ilex opaca* Ait.
Flowering Dogwood—*Cornus florida* L.
Crataegus spp.

Other trees and shrubs of common occurence are:

Wax Myrtle—*Myrica cerifera L.*
Black Gum—*Nyssa sylvatica* Marsh.
Birch— *Betula-nigra* L.

The understory of this zone is composed of the shrubby forms of the plants listed above as well as numerous herbaceous plants that vary greatly with the seasons.

The second, moving towards the center of the bog, could well be divided into very moist and semi-moist units. From the over all viewpoint, it is an area of the low shrubs, wax myrtle and yaupon, and several grasses including *Andropogon ternarius* Michx. (the most abundant), *Erianthus saccharoides Michx., Paspalum plicatulum* Michx. and *Paincum* spp. The various plants form almost pure stands at intervals.

Scattered throughout zone two are communities of the insectivorous pitcher plant *Sarracenia sledgei* MacFarlane. Almost without exception, these plant communities are associated with the "boggy" areas. The surface of these areas feels like gelatin. When it is walked upon, the ground shakes for several feet around. These places vary in diameter from five to fifteen feet. They are essentially oval in outline and seem to be ponds or sloughs that have become filled with fine organic material from the plants nearby. The roots of the surface plants have formed a very dense network. The net result is the flexible "wavy" surface that is so peculiar.

Other than the pitcher plant, there is a large number of other distinct plants found only in association with these areas. There are two orchids, rose pogonia *Pogonia ophioglossoides* (1.) Ker Gawl that is abundant in late April and swamp tresses *Spiranthes cerna* (L.) L. C. Rich. Correll in mid summer. In early spring and through most of the summer the pipeworts *Eriocaulon* spp. are abundant. These plants are called the composites of the monocots as they have their flowers in compact heads that resemble those of members of the compositae. There are two forms of another insectivorous plant, the bladderwort, *Utricularia* spp. that are abundant in the spring. The sundew *Drosera annua* Reed is also found in abundance in the sandy, moist regions of the whole area. *Rhexia mariana* L. the meadow beauty is very abundant in mid-spring and gives the area a purple hue by its numerous bright flowers. Two diminutive plants, bog moss *Mayaca aubleti* Michx. and *Sphagnum* or peat most *Sphagnum subsecundum* Nees and *S. imbricatum* Hornsh., form a dense matte on the surface wherever there is enough light for their growth. (The mosses determined by A. LeRoy Andrews).

This middle zone exhibits the most outstanding seasonal aspect changes of the three. The winter aspect, which lasts from November to late February, is characterized by the dead grasses and the evergreen wax myrtle. In early spring, the pitcher plants, velvety panic grass *Panicum scoparium* Lam., two ferns *Osmunda regalis* L. the royal fern and *Osmunda cinnamonea* L. the cinnamon fern give the bog a green mantle. Soon after, the grasses appear to take over and continue to dominate for most of the summer in a green condition. During that period, however, *Helianthus angustifolia* L. the narrow-leafed sunflower gets to be very abundant. Following are two members of the parsley family *Ptliminium costatum* (Ell.) Raf. and *Cicuta mexicana* C. and R. With the gradual disappearance of the parsleys and the death of most of the other herbaceous forms, the bog assumes its winter aspect.

There is an encroachment of both the other two zones into zone two in several places. The resulting small shrub and tree communities have interesting mixtures of the floras.

Zone three is composed for the most part of wax myrtle and yaupon, although many smaller plants form an integral part of the whole community. These plants weave so thick a network that passage is almost impossible. The soil here is dryer than that in zone two, due in part to at least a slight elevation along the stream's edge. The most frequently observed plants in zone three, other than the dominants, were as follows:

Dewberry—*Rubus velox* Bailey

Stretchberries—*Smilax laurifolia* L.
Smilax glauca Walt.
Smilax rotundifolia L.

Rattan vine—*Berchemia scandens* (Hill) Trel.

Peppervine—*Cissus arborea* (L.) Des Moulins

Approximately the same zonation is exhibited on both sides of the stream, although less distinctly and in a shorter space on the south side where the slope is more abrupt.

Field analyses with colorimetric methods give the following approximate pH readings. Zone one, the woods, pH6; zone two, the soil, pH5, the standing water pH4; and zone three, the soil, pH6, the water in the stream, pH5.

The bog under consideration is located approximately fifteen miles east of New Baden in Robertson County. It is in the Carrizo sands of the Claiborne group, geologically. The bog has assumed a general "C" shape and follows a small stream in an east-west direction. A good supply of seepage water and a sort of natural reservoir with the resultant accumulation of organic materials seem to be the major reasons for the formation of the bog.

The vegetation forms three distinct natural zones. The first is the forest of the oak-hickory association, with black jack, post oak, sand jack, Buckley's hickory and yaupon being the dominants. The second zone contains the real "boggy" areas and is dominated by wax myrtle, *Andropogon ternarius, Sarracenia sledgei,* and several grasses. This area exhibits outstanding seasonal aspect changes and has many plants that cannot be found again in most parts of the state. The third zone is along the stream that runs through the middle of the bog. Its vegetational constituents are yaupon, wax myrtle, three species of stretchberry, *Rubus velox,* and several other vines and understory plants.

This report is preliminary and further study is in progress.

THE MACARTNEY ROSE

(*Rosa bracteata*—Windland)

I. T. Taylor
County Superintendent of Public Instruction
Jackson County
Edna — Texas

COMMON NAME

Wild Rose, Rose, Macartney's Rose, Rosa Blanda, Hedge Rose.

DESCRIPTION

Evergreen shrub with erect to drooping stems that form a climbing or trailing woody vine-tomentose, with stout hooks and mostly paired prickles. The leaflets five to nine, oval to obovate, crenately serrulate, bright green above and somewhat shining almost glabrous underneath, one-half to two inches long; stipules slightly obovate and pectinate. The flowers are solitary, short-stemmed, white, one and one-half to two inches across with large, lacineated, pubescent bacts at base; sepals reflexed after flowering, densely tomentose; receptacle tomentose; fruit globose, one-half to one inch across, orange-red, woolly.

Blooming period from April to June and sporadically until frost. When left undisturbed many of the plants develop into thick motted mounds, ten to fifteen feet high and many yards thick. These may extend from a half-mile to a mile in length, forming impenetrable thickets along fence rows, drainage ditches, canals, creeks and river bottoms, choking out all other growth and apparently impoverishing the soil wherever it is found.

HISTORY AND RANGE

The Macartney Rose originated in China and was first introduced into the United States, in 1793, by a sailor named Macartney, for whom it is named. It has since become naturalized from Virginia through Florida and the other Gulf states to Texas. Originally, because of its extremely dense growth, this rose was planted in various parts of the South for wind breaks, hedges, and to stop erosion; and some of these early plantings, made a century ago, are still growing luxuriantly.

There is no record of its first introduction into Texas. However, so well were our climate and soils suited to it, it was not long until the familiar garden and hedgerow plant had spread widely and become a pest of the worst type. In Jackson County today several thousand acres are covered with it, while in Texas as a whole, it has rendered probably 200,000 acres useless.

METHODS OF DISTRIBUTION

We have already noted the transplantation of this rose to various parts of the South by man. However, it is by natural means that it has been spread so widely. In dry years cattle feed on the rose hips, generally in the late summer or early fall, after the grass is gone and the rose bushes have made hundreds and hundreds of seed pods. The seeds, which are resistant to the digestive juices, are then spread in the manure and, as the cattle move on to uninfested land, they leave these seeds nicely fertilized, ready to germinate and grow the following spring. In an uncompleted experiment, the A and M College of Texas has arrived at the conclusion that for every one hundred rose seeds eaten, a reasonable expectation is that twenty-eight new rose plants will be started. With each hip containing over fifty seeds, it is easy to conclude that the plant has a good chance of covering a lot of territory.

In wet weather, during the late fall, cattle spread this plant by another means. Walking through areas infested with the rose, they pick up parts of the rose stems and roots between their hooves, carrying them to other parts of the pasture, thus resetting them in areas where they will grow and thrive.

Claims have been made that foxes, raccoons and opossums eat the fruit and spread the seeds, but there is little or no evidence to support this contention, and it is not considered likely. However, pocket gophers feed on the roots and probably eat some of the fruit. These animals also store food for the winter, part of which consists of bits of Macartney rose roots two to four inches long. Those they do not eat during the winter will sprout the next spring, starting new haycock-like clumps.

However, birds compose the greatest medium of natural distribution. Cardinals, mocking birds, cedar wax wings and robins all are very fond of the rose hips, feeding heavily on them in the late fall and early winter and the seeds are scattered far and wide in this manner.

Another lesser cause of distribution, but one serving to spread the plants extremely widely may be due to shipping cattle from rose infested areas to those where this pest has not yet obtained a foot hold. Stock cars and trucks would thus be distributing agents, as would stockyards disposing of manure.

WILDLIFE PROTECTION

It is a dark cloud that has no silver lining and it would be bad indeed if we could say nothing good of the Macartney Rose. Rose clumps give cover and protection to wild life along the gulf coast of Texas. They are a favorite abode for pocket gophers to which the rose furnishes food, shelter and protection. These clumps also give protection to armadilloes, skunks, opossums, foxes, wolves, snakes and field rats and furnish cover and nesting places for birds. Quail, particularly, want nothing better than a rose infested pasture for cover and protection.

CONTROL

The control of this rose is becoming a serious question. It apparently has no enemies. No diseases or insects attack it, and Nature gives no aid to man in this problem. As a result, in some areas of the state (as we have already mentioned), these plants are so numerous that considerable areas lie idle and, in the last ten years have spread over grazing land so rapidly that range specialists have started serious studies of this pest to determine how best to control it.

The usual method of grubbing out the clumps costs from $20.00 to

$65.00 per acre and is not satisfactory. It does not destroy the rose in an area, but merely holds it in check.

Treatments with 2, 4-D at the rate of one and one-half pounds per hundred gallons per acre give some results but do not eradicate the plant. In an experiment with this chemical, Cyrus L. Cook, Assistant County Agent of Victoria, obtained the following results:

"A close examination of wild rose test plots where double strength 2, 4-D was used showed almost one hundred percent kill. In other places the same concentration got only about a twenty-five percent kill. A dilute solution got about seventy-six percent kill in some places. In others the same dilute solution got very little if any results. So at present it is hard to say just what results we can expect from the 2, 4-D chemical in the eradication of wild roses."

The A and M study on the use of rose hips as food by cattle showed that about eighty-five percent of the seeds are passed by an animal within three days after they are eaten. If the ranchmen will isolate for three days cattle which have had access to the Macartney rose he will go a long way towards cutting down the spread of the plant, as shipment of such cattle has been responsible for the destruction of much previously uninfested grazing land.

Whenever possible, the best means of control is to plant rice for two consecutive years on the infested land. The water used in irrigating and cultivating the rice will eradicate the Macartney rose and has, wherever rice is grown on the gulf coast, been responsible for holding this pest in check.

This rose is a pest of the worst kind, and must be dealt with in the near future or thousands of acres of land will have to be turned back to Nature as unfit for human use.

A DEMONSTRATION OF STAINED ROOT HAIRS ON GRASS SEEDLINGS

Carol McCall
Biology Department, Baylor University
Waco, Texas

The laboraory needs of General Botany classes in Baylor University served as the stimulus for the work described in the ensuing report. Prescribed studies of root systems, with particular attention being given to root hair formation zones and microscopic structural details, proved difficult because of variations in germination time of seeds and in the qualitative structures of seedlings which did germinate. By modification of the usual technique methods, a set of permanent slides was made which proved satisfactory for the class needs.

MATERIAL AND METHODS

Seeds of *Agrostis alba,* commonly known as "redtopped grass", are germinated on moistened filter paper in petri dishes. This requires a period of from three to five days in the dark. The dark-room germination results in a more rapid elongation of cells in the roots, and also insures less evaporation of moisture from the dishes. The seeds are vernalized, or refrigerated, until the time for germination, in order that their development may be speeded up.

The seedlings are killed and fixed in formalin-acetic-acid (Krajian, 1940) by simply filling the lower half of a petri dish with the solution and agitating the dish frequently for about a thirty-minute period. The fixing reagent is drained off of the seedlings, and four or five changes of distilled water are used in washing out the fixative. The seedlings are then covered with Delafield's hematoxylin solution for at least thirty minutes. Microscopic examination of the seedlings during the staining process shows the roots to be heavily over-stained; this is compensated for by the destaining activity of the glycerin in the following steps of the procedure. The stained seedlings are washed four or five times with tap water, and are now ready for mounting.

Selection of the seedlings to be used is made with the petri dish under a dissecting microscope, and laboratory forceps are used to grasp the coleoptile of each seedling for the transfer from the dish to a slide. Each seedling is placed on a slide in the proper position for a permanent mount, and ten per cent glycerin added as the mounting medium. The slide tray is placed in a dust-free chamber for approximately forty-eight hours, or until the glycerin concentrates, then a drop of pure glycerin is added to each seedling, and a small cover slip, No. 1A-7/8 is dropped into position on the glycerin. An excess glycerin is removed from around the edge of the cover slip with blotter paper. A drop of clarite is placed on the small cover slip, and a larger slip, No. 2-18 mm., is dropped into position, taking care to eliminate air bubbles. This method of double mounting is necessary for two reasons: clarite and glycerin are immiscible, causing an unsightly circling effect where the two materials meet, and glycerin does not seal, making the larger cover slip with clarite seal essential for permanent slide preparations. If the glycerin should penetrate the clarite ring, it may be necessary to seal the cover slips with an asphaltum ring, applied by means of a brush and slide turntable.

Final cleaning of the slides includes rubbing with xylolalcohol mixture, light washing with Vel and water, and polishing with a lint-free cloth.

Various other methods tried in the procedure proved less efficient than the method outlined. Grass seeds were germinated on top of the water in a finger bowl, but the volume of water made fixing, washing without loss, and staining extremely difficult. Using the given procedure for fixing, washing, and staining, one group of seedlings was run up through the alcohol series, with 10-20-30-40-50-60-70-85-95% and absolute alcohol concentrations, with a ten-minute period in each alcohol, and final concentration in ten per cent glycerin. Not only did the procedure require more time and extensive preparation of solutions, but the seedlings became matted, trash accumulated about the roots, and no better results were obtained from the alcohol series method. Another experimental procedure was that of adding ten per cent glycerin to the seedlings in the perti dish and allowing concentration to occur en masse. When each seedling was selected and mounted in pure glycerin on the slide, the root hairs were matted, or were destroyed in the transfer.

The mounting technique itself may be more easily carried out by some workers by concentrating the seedling in ten per cent glycerin on one of the cover slips, adding pure glycerin and the other slip later, and then dropping the two-slip combination into position on the slide where a drop of clarite has been placed.

A microscopical study of the resultant permanent slides of grass seedlings revealed slightly stained structures, including the root hair cells, nuclei and peripheral cytoplasm; the vascular elements arrangement of the asymmetrical root cap cells; the regions of root hair formation and of cell elongation; and the appearance of distorted and branched root hairs. Possibly the most interesting feature of the slides is the fact that they afford a means of tracing root hair development, from a slight bulge on the side of the cell through root hairs of varying lengths, until the mature root hairs with the tube nucleus is revealed.

THE ROLE OF DENITRIFYING BACTERIA IN THE GENESIS OF FORMATIONS FOUND IN THE CARLSBAD CAVERN

M. Gerundo, M.D., Ph.D. and Guydell L. Schwartz, B.S., M.A.
From the Department of Laboratories
Lubbock Memorial Hospital
Lubbock, Texas

Cave formations have been considered as due to water erosion and sedimentation of lime salts dissolved by water. Little or no attention has been paid to the possibility that bacteria in the soil may be active agents in the precipitation of lime and may take active participation in the origin of these structures. It is our aim to present the preliminary phase of our work and to offer the hypothesis that geological evolution is due in part to the development of biological factors.

MATERIALS AND METHODS

Samples of soil were collected at various levels from areas where tourists are not allowed. The procedure consisted in scraping the soil surface and then collecting the sample in sterile jars. The areas covered in this first survey were:

1. A rusty colored dry surface near the top.
2. An area nearby covered by molds.
3. Soil from the bottom of a green pool, midway down near the Baby Hippo.
4. Water from a pool in the rear of the Papoose Room.
5. Soil embedded in gypsum midway between Baby Hippo and King's Palace.
6. Thin crust forming over the surface of water in a stagnant pool in Big Room.
7. Soil at the base of a huge stalagmite still in process of formation in the Big Room.

The media used were 12% gelatin in tap water, Winogradsky's medium for nitrifying bacteria, nitrate glucose medium, peptone potassium nitrate agar, Gran's medium, lactate Ringer's solution. After various experimental trials, a medium was prepared as follows:

Calcium nitrate (in separate solution added after sterilization)	2.0 grams
Dipotassium phosphate	1.0 grams
Malic acid	2.0 grams
Succinic acid	1.0 grams
Sodium chloride	15.0 grams
Magnesium sulphate	1.0 grams
Water, distilled	1000 cc.

Adjustment of pH was made at first, but growth was rapid and more abundant when the medium was left acid.

For purpose of identifications, subcultures were made on phenol red carbohydrate media, and Kligler's, Russell's, McConkey's.

One gram of soil was inoculated in 500 cc. of liquid medium. After thorough shaking to make a homogeneous emulsion, transfer in the amounts of one, two, five and ten milliliters were made to flasks containing 100 cc. of medium.

RESULTS

Direct bacterioscopic examination from the soil of the shallow green pool showed numerous small bacilli, occasional bacillary forms with capsule, numerous long bacilli with bipolar granules and a large number of coccobacilli. All these bacteria were gram-negative except for a few gram-positive coccoid forms. Direct examination of the soil at the base of the stalagmite in process of evolution showed numerous crystals of calcium, carbonate and oxalate and small motile gram-negative bacilli, many of which had polar granules.

Most of the culture studies on several areas need only a passing comment. Cultures from the rusty dry area and nearby area were scanty, did not reduce nitrate but formed nitrite from ammonia. Cultures on potassium nitrate-glucose medium from the dry area which has been designated as soil in gypsum showed mostly colonies of fungi and gave no nitrite reaction.

The soil from the green pool gave good bacterial growth in nitrate agar, lactate Ringer's solution and gelatin. On subculture two types of colonies were observed, one of yeast cells and the other of small gram-negative bacilli. Both yeasts and bacteria reduced nitrate to nitrite. The bacilli grew well in peptone media and fermented dextrose and lactose producing acid but no gas. They grew well on McConkey's agar and produced no H_2S in Kligler's medium. In fluid media they produced sediment, which sedimented to the bottom. In the original mixed culture some amorphous hyaline structures were seen, around which yeast bodies were arranged in circles. The identity of these structures was not clearly established.

The bacteria from the base of the formation liquefied gelatin in which they formed white-grayish round colonies with irregular contour, slightly depressed center and granular appearance. The surface colonies became rapidly confluent and formed a viscid membrane which fell to the bottom in large shreds through the liquefied medium. In Gran's medium and in potassium nitrate-glucose medium the bacteria produced a slimy, soft, elastic membrane enveloping sand particles into a large mass which did not break loose even on energetic shaking. The bacteria were motile, small, about 1.5 to 3 microns, gram-negative and sometimes contained polar granules. They did not grow in Winogradsky's medium without potassium nitrate and on Sabourand's plates and grew scantily in lactate Ringer's only after heavy inoculum. Their growth was somewhat better and more rapid on media containing peptone and very luxuriant on our calcium nitrate medium, but was inhibited on McConkey's plates, probably because of the presence of bile salts. On nitrate agar plates the colonies were small, pin-point, rather translucent; in fluid media there was slight turbidity with floccular precipitate. Other characteristics noted were rapid reduction of nitrates to nitrites; precipitation of calcium carbonate; production of ammonia and of H_2S; acid, then alkaline in presence of glucose and lactose. Microscopic examination of the sediment of culture media revealed grains of sand around which some amorphous matter had stratified in concentric layers and numerous crystals. The sediment was promptly dissolved by dilute hydrochloric acid with evolution of gas bubbles.

DISCUSSION

As we understand it, the common geological interpretation of the formations is based upon water erosion and sedimentation. Although at the present time it is not probable that a solution of the problem is at hand, the biological factor in the formation of these structures may play a very important role.

It is significant in our preliminary work that active denitrifying bacteria were predominant in those areas of the cave where structures are still in progress of formation. Those areas which—let us say—have already settled and become stationary contained no denitrifying bacteria.

If the structures were dependent only on water erosion, those areas which do contain abundant water should show more rapidly growing formations. Instead, it appears that active formations are possibly only where there is a moderate degree of moisture.

It is said that denitrifying bacteria have wide distribution in nature and in soils; still no Carlsbad Caverns are formed. This is a sound statement, but it does not take into account the environment, the atmospheric conditions, the abundance of CO_2, protection from human or natural interferences, etc. If the soil of the cavern were plowed under every spring and fall, and the whole of the cavern had the same amount of sunshine, oxygenation and wind erosion as the soil on the surface, there would not be any wonder to admire.

The probable mechanism presented here as a hypothesis is that bacteria acting on nitrogenous organic matter will decompose it to ammonium carbonate which then will interact with calcium sulphate, or other calcium salts present in the soil according to the equation $(NH_4)_2CO_3 + Ca\ R = CaCo_3 + (NH_4)_2R$, where R represents the acid radicle of a calcium salt. Drew in 1914 called attention to the presence of denitrifying bacteria in sea-water in tropical seas and attributed to them an important role in the formation of extensive chalky mud flats of the Great Bahama Bank and around the Florida Keys. He isolated a bacterium, Pseudomonas calcis, which produced precipitation of calcium carbonate in the culture flasks. When sand or finely powdered calcium sulphate was added to the medium, calcium carbonate would aggregate around the particles like a concretion around a central nucleus. A large concretion often would be found having a number of smaller concretions around it, in an arrangement suggestive of freely budding yeast cells.

The description of this author, whose work seems entirely forgotten, parallels our findings in regard to the formation and the green pool. Above we have described these concentric amorphous structures, as well as crystalline structures around which yeast cells arranged in circle. In our calcium nitrate medium, precipitation and sedimentation occurred in a peculiar radial pattern with numerous holes throughout, which was reminiscent of a cross section of sponge, or of a crochet pattern. This sediment was promptly soluble in dilute hydrochloric acid with evolution of gas bubbles.

The morphological and biochemical characteristics of the bacterium isolated by Drew correspond fairly well to those we have described for the denitrifying bacteria found in the formation. Therefore, it is considered that the strain we have isolated is identical with Pseudomonas calcis (Drew). However, it is probable that in the soil of Carlsbad Cavern various species may occur which contribute to the formation of structures.

This work is in its preliminary phase. We do not hold that we have answered a problem which had its origin in geological eras nor do we hold that one single factor is operative. At this time our hypothesis is presented as a suggestion or indication of work to be done. It is felt that the presence of denitrifying bacteria in areas of active formation of the cavern is not just an accidental finding but an essential part of terrestrial evolution. The phenomenon may be of general nature and very likely true also for similar structures throughout the world.

LITERATURE CITED

G. **Harold Drew**—1914—On the precipitation of calcium carbonate in the sea by marine bacteria, and on the action of denitrifying bacteria in tropical and temperate seas. Carnegie Institution Publication **182**: 7-48.

CHLOROPHYCEAE OF ERATH COUNTY

Lula C. Gough
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Tarleton State College
Stephenville, Texas

CHLOROPHYCEAE OF ERATH COUNTY

INTRODUCTION

The county in which the plants given below were found is located near the cener of Texas. It lies between parallels 31°50' and 32°31' and between meridians 97°50' and 99°32'. The elevation ranges from one thousand feet around Bluffdale to seventeen hundred and fifty feet south of Thurber.

The mean annual temperature of the county is between sixty-five and seventy degrees, but the section of country is so far inland that there are large seasonal and diurnal ranges. It will be interesting to note, however, that these ranges do not affect the growth of Chloropyceae to so great a degree as they do the land plants.

The rainfall of the county averages from twenty-five to thirty inches. From February 1926 till February 1927, it was twenty-five and eighty-eight one hundredths inches. The winter and spring months received about two-thirds of this precipitation. The maximum in Stephenville for that year was five and eighty-three hundredth inches for the month of May, and the minimum was none for the month of February. Local rain storms are sometimes excessive, sweeping temporarily all traces of the Chlorophyceae. Gravel bottoms and rocky sides of the streams, however, seem to hold the spores, and the group is not long in re-asserting itself.

The average evaporation capacity of the atmosphere is about fifty inches, but in the summer season it ranges around seventy-five inches, and many of the stock ponds and streams either dry out entirely or stand in pools. A few of the larger streams continue to run throughout the year, but they become quite sluggish and it is in these that our most fertile fields are found for the Algae. The drainage on the prairie part of the county is simple, without extensive denundation. The stream beds are broad and have only slight banks. In the rougher country towards the Callahan divide, small canyons appear, the run off is rapid, and many of the streams are of the wet weather variety.

While the sluggish streams were sources for the most active study, standing water, where these bodies are perennial, were quite productive. Club lake at Stephenville always gave fruitful returns for research. Thurber Lake bore few filiaments and those were chiefly oedogonia, but the smaller growths were constantly to be found about the bases of cat tails and on the underneath of lily leaves.

Collecting was at its best in the fall, for there were times in which it seemed that each plant was rivaling its neighbor in its effort to make ample preparation for the survival of its species. Reproductive bodies were found in all stages. Collecting was good through the winter. There were few heavy rains and vegetative masses seemed to withstand the run-offs. Sporing on many of the plants did not cease throughout the year. Freezing affected developments little. Chromatophores were sometimes disturbed or broken down, but enough of the plants were left uninjured to make continuous functioning seemed unimpaired. Summer was least profitable in its collecting possibilities. This was due either to the fact that many of the water supplies were dry, or to the scarcity of reproductive bodies. The plants in evidence at this season seemed to be enlarging the thallus rather than producing those spores which are so often necessary to identification.

Since it is impossible to classify Chlorophyceae in the open, all specimens were carried to the laboratory, sorted by the aid of the microscope, and the duplicates discarded.

The writer preserved her specimens largely in solutions, the most preferred being "Universal Fixative." This preservative is made up of 2½ c.c.

of acetic acid and 6½ c.c. of formalin added to 100 c.c. of 50% alcohol. The plants retained their color well in this solution and the transfer to permanent slides was rapid and easy. Temporary slides of one celled plants or of rare specimens were made into permanent slides at once.

While Collins in his "Green Algae of North America" recognizes the drying method of preservation as the best, the writer of this article found it almost valueless. Preservation on mica is good, but the making of the permanent slides seemed more logical. Preservation by drying either on paper or on mica, would, of course, make a less cumbersome form for herbarium use, and would be less subject to destruction.

To preserve the specimens by drying Collins says to place them in water, slip the mounting paper beneath them, and raise. The paper bearing the plant is placed on a thick dryer, a cloth put over the specimen, and then a second dryer. The absorbing sheets are changed as soon as they become moist, but the cloth is not removed till the plant is entirely dry. The plant will be found to cling to the mounting paper. Minute forms are spread thinly on paper and allowed to dry without cover or pressure. Or, better still, water is added to the minute forms and they are dropped from a pipette on to mica where they can be examined without removal.

The plants studied were largely of an attached nature, their long filiaments being drawn down stream by the running water. Some of the smaller plants were attached to these filiaments, while others of them grew as plankton, and were floating where the current was checked. Many of them were found at the bottom of the aquaria where specimens had been retained for future study.

The plates given at the close of the paper are camera lucida drawings, and are only illustrative of the less familiar specimens. The scale is given for the plate, unless the different drawings on a page are of different scales and then the measure is given with each drawing.

In the classification of Chlorophyceae which follows, both the outline and the descriptions have followed those given by Collins in his book "The Green Algae of North America," except in the case of the Desmidaceae. Here Cook's "British Desmids," 1887, was the authority followed.

Class I. Heterocontia
- Order I. Confervales
  - Family I. Confervaceae
    - Genus I. Tribonema
      - Species I. *T. bombycinia* (Agardh) Derb. and Sol.
      - II. *T. utriculosum* Kutz.
    - Genus II. Ophiocytium
      - Species I. O. parvulum var. circinatum (Wolle) Lemmerman.

Class II. Chlorophyceae
- Order I. Conjugales
  - Family I. Desmidaceae
    - Sec. A. Leiosporae
      - Genus I. Closterium
        - Species 1. *C. moniliferum* Ehr. Inf.

2. C. *dianae* Ehr. Infus.
3. C. *striolatum* Ehr. Abh. Berl. Akd.

Sec. B. Cosmosporae
Genus I. Euastrum
Species 1. E. verrucosum Ehr. Abh. Berl. Akd.
Genus II. Cosmarium
Species 1. C. *pseudonitidulum* Nordst.
2. C. *undulatum* Corda. Alm. Carls.
3. C. *reniforme* Archer
4. C. *turpini* Breb. Liste. Desm.
5. C. *coelatum* Ralfs. Desm.
6. C. *cyclinium* Lundell. Desm.
7. C. *moniliforme* (Turpe) Ralfs. Desm.
8. C. *Cymatopleurum* Nordst. Desm. Spetz.
Genus III. Staurastrum
Species 1. S. *bullosum* Bennet, Roy
2. S. *punctulatum* Breb.

Family II. Zygnemaceae.

Genus I. Zygnema
Species 1. Z. *pectinatum* (Vauch) Agardh.
2. Z. *cruciatum* (Vauch) Agardh.
3. Z. *purpurem* Wolle.
4. Z. *stellinum* (Muller) Agardh.
Genus II. Spirogyra.
Species 1. S. *portocalis* (Muller) Cleve
2. S. *condensata* (Vauch) Kutzing
3. S. *varians* (Hass) Kutzing
4. S. *dubia* Kutzing
5. S. *bellis* (Hass) Cleve
6. S. *setiformis* (Roth) Kutzing
7. S. *ternata* Ripart
8. S. *weberi* Kutzing
9. S. *spreeiana* Rabenhorst
10. S. *quadrata* (Hass) Petit
11. S. *grevilleana* (Hass.) Kutzing

Family III. Mesocarpaceae

Genus I. Mougeotia
Species 1. M. *genuflexa* (Dillw) Agardh
2. M. *parvula* Hassall
3. M. *sphaerocarpa* Wolle
4. M. *crassa* (Wolle) DeTonti
5. M. *quadrangulata* Hassall
Genus II. Gonetonema
Species 1. G. ventricosum Wittrock

Order II. Volvocales

Family I. Chlamydomonadaceae
Genus I. Chlamydomonas
Species 1. C. *communis* Snow

Genus II. Haematococcus
Species 1. *H. pluvialis* Flotow
Genus III. Chlorogonium
Species 1. *C. euchlorum* Ehrenberg
Family II. Volvocaceae
Genus 1. Pandorum
Species 1. *P. morum* (Hull) Bory
Family III. Tetrasporaceae
Genus I. Palmella
Species 1. *P. miniatus* Leiblein
Genus II. Tetraspora
Species 1. *T. gelatinosa* (Vauch) Desvaux
2. *T. lubrica* (Roth) Agardh
Genus III. Innefigiata
Species 1. *I. neglecta* W. and G. S. West

Order III. Protococcales

Family I. Protococcaceae
Genus I. Chlorococcum
Species 1. *C. humicola* (Nag) Rahenhorst
Genus II. Characium
Species 1. *C. naegelii* A. Baun
2. *C. ambiguum* Hermann
Family II. Scenedesmaceae
Genus I. Palmellococcus
Species 1. *P. miniatus* (Leiblein) Chodat
Genus II. Schizochlamys
Species 1. *S. gelatinosa* A. Braun
Genus III. Scenedesmus
Species 1. *S. obliquus* (Turp.) Kutzing
2. *S. bijuga* (Turp.) Wittr.
Family III. Hydrodictyaceae
Genus I. Pediastrum
Species 1. *P. boryanum* (Turp.) Meneghini

Order IV. Ulotrichales

Family I. Ulotrichaceae
Genus I. Ulothrix
Species 1. *U. zonata* (Web. and Mohr.) Kutzing
2. *U. osillarina* Kutzing
Genus II. Schizomeris
Species 1. *S. leibleinii* Kutzing
Genus III. Microspora
Species 1. *M. amoena* (Kutz.) Rabenhorst
2. flocca *Vauch* Thuret
Family II. Praiosolaceae
Genus I. Prasiola
Species 1. *P. crispa* (Lightf.) Meneghihi
Genus II. Schizogonium
Species 1. *S. murale* Kutzing
Family III. Oedogoniaceae

Genus I. Oedogenium
Species 1. *Oe. varians* Wittrock and Lund
2. *Oe. boscii* (LeCl.) A. Braun
3. *Oe borisianum* (LeCl)) Wittrock
Genus II. Bulbocheate
Species 1. *B. mirabilis* Wittrock
Family IV. Chaetophoraceae
Genus I. Diphlocheate
Species 1. *D. solitaria* Collins
Genus II. Chaetophora
Species 1. *C. elegans* (Roth) Agardh
2. *C. attenuata* Hazen
3. *C. incrassata* (Huds.) Hazen
Genus III. Draparnarldia
Species 1. *D. glomerata* (Vauch.) Agardh
Genus IV. Stigeoclonium
Species 1. *S. lubricum* (Dillw) Kutzing
Genus V. Pleurococcus
Species 1. *P. vulgaris* Meneghini
Genus VI. Gloicoccus
Species II. *G. mucosus* A. Braun
Family V. Coleochaetaceae
Genus I. Coleocheate
Species 1. *C. scutata* Brebisson
Family VI. Herposteiraceae
Genus I. Herposteiron
Species 1. *H. confervicola* Nageli

Order V. Siphonocladiales

Family I. Cladophoraceae
Genus I. Cladophora
Species 1. *C. glomerata* (L) Kutzing
2. *C. canalicularis* (Roth) Kutzing
Genus II. Pithophora
Species 1. *P. varia* Wille.
2. *P. oedogonia* (Mont) Wittrock
Family II. Dascladaceae
Genus I. Bathophora
Species 1. *B. oerstedi* Agardh

Order VI. Siphonales

Family I. Vaucheriaceae
Genus I. Vaucheria
Species 1. *V. sessilis* (Vauch) DeCandole
2. *V. terrestris* (Vauch) DeCandole
3. *V. germinata* (Vauch) DeCandole
4. *V. longipes* Collins
Genus II. Dichotomosiphon
Species 1. *D. tuberosus* (A. Braun)

CHLOROPHYCEAE OF ERATH COUNTY

Class I. HETEROKONTAE.

Motile cells with two cilia of unequal length; chromatophore more or less distinctly yellow green; reserve material oil, not starch; no pyrenoids.

Order Confervales.

KEY TO THE ORDER OF CONFERVALES.

1. Chiefly aquatic; filamentous or unicellular, without branching prolongations.
2. Unicellular, or filamentous; cell wall with little cellulose; sexual reproduction unknown. 1. CONFERVACEAE.

Family I. CONFERVACEAE.

Cells free, or united in attached or free monosiphonous filaments; cell wall with little cellulose, mostly pectin; chromatophores usually many, disk-shaped, always without pyrenoid, cells containing more or less oily matter but no starch; one or more nuclei; asexual reproduction by zoospores with two cilia of unequal length, or by aplanospores which often seem to take the place of zoospores under certain conditions of environment; all plants of fresh water.

KEY TO THE GENERA OF CONFERVACEAE

1. Cell elongate. 2.
   2. Cells united into filaments. 1. TRIBONEMA
2. Cells solitary or attached by their slender bases. 2. OPHIOCYTIUM.

1. Tribonema Agardh.

Filament at first attached by a special basal cell, later floating. Chromatophores disk shaped, yellowish green, without starch, but producing oil, two or several in a cell. Cell-wall thin, formed by deposition of layers composed largely of pectic acid with little cellulose. For the dispersal of the zoospores, the cells pull apart from the middle, so that H-shaped sections are left.

T. bombycinum (Agardh.) Derb. and Sol. Filaments forming a solid, yellowish or green floccose mass, 6-11 u. in diam. when mature; cells cylindrical or somewhat inflated, 2-4 times as long as the diameter; chromatophores several in a cell, small or of moderate size, scattered or crowded, glistening oil drops often numerous; cell wall rather thin. Aquarium, Tarleton State College.

T. utriculosum (Kutz.) Filaments long and often inflated, but sometimes cylindrical; cells 11-16.5 u. in diameter, 1½-6 times as long; chromatophores large and often crowded; cell wall thicker than in the smaller species. Plankton in drain from Club lake, Stephenville.

2. Ophiocytium Naegeli, 1849.

Cells free or attached to water plants, multinucleate, cylindrical or claviform, one end frequently capitately swollen, straight, arched, curved into S form spirally, solitary or in umbellate or corymbose families; chromatophores many, parietal, without pyrenoid, cells sometimes containing yellowish globules; asexual reproduction by aplanospores, or by biciliate, ovoid, oblong zoospores, formed few to many in the cell, escaping by the breaking off of the cap-like end of the cell; in some species germinating directly at the summit of the mother cell, in others entirely independently.

1. O. *Parvulum* Var. *Circinatum* (Wolle) Lemmerman, 1899. Cells solitary, 10-13 u. diameter, in a spiral of two to many turns, both ends rounded. Always in spiral. Water trough at Morgan's Mill. Plate II, figure 9.

Class II. CHLOROPHYCEAE.

Algae of the true green color, usually producing starch, almost always with pyrenoids; reproduction in most cases by pyriform zoospores, with cilia of equal length, attached to the smaller end; mostly two, sometimes four, in a few genera many cilia; zoogametes of similar forms, with two or four cilia.

Motionless spores of various kinds, and sexual reproduction by oogonia and antheridia, are found in many genera.

KEY TO THE ORDERS OF CHLOROPHYCEAE

1. Fronds of one or more cells. 2.
1. Fronds usually of relatively large size, multinucleate, without distinction of cells. 6. SIPHONALES.
    2. Vegetative cells ciliate and motile, always or except during resting periods, or easily passing into a motile condition. 2. VOLVOCALES.
    2. Vegetative cells motionless; reproductive cells motile or not. 3.
3. Reproduction by zygospores formed by the union of two non-motile cells. 1. CONJUGALES.
3. Reproduction by zoospores, zoogametes, or aplanospores, not by zygotes as above. 4.
    4. Cells solitary or in spherical or net-like combinations. 3. PROTOCOCCALES.
    4. Cells forming simple or branched filaments or membranes, rarely proliferously branching and vesicular cells. 5.
5. Cells uninucleate, chromatophore usually single, disk-, net-, or star-shaped. 4. ULOTRICHALES.
4. Cells multinucleate, chromatophore net-shaped, or of numerous small disks in a cell. 5. SIPHONOCLADIALES.

Order I. Conjugales.

Grass-green algae, starch forming, with cell walls of cellulose, whose cells divide in only one direction, and are either isolated or in filaments; not incrusted with lime. Zygospores formed by the union of the protoplasm of two similar or only slightly different cells "aplanogametes"; after a longer or shorter resting period the outer membrane of the spore breaks, and a new vegetative development sets in. Thick walled resting cells "akinetes" and asexual spores "aplanospores" sometimes formed; no motile spores.

KEY TO THE FAMILIES OF CONJUGALES.

1. Cells usually diveded by constriction into symmetrical halves; solitary or in filaments; the cells arising from the germinating zygospores either

taking the normal form or producing 2-8 such forms. 1. DESMIDACEAE.
1. Cells cylindrical, without constriction, always united into filaments; the new filament always formed directly from the zygospore. 2.
2. The entire protoplasmic contents of the conjugating cells uniting to form the spore. 2. ZYGNEMACEAE.
2. Only a part of the contents of the conjugating cells used for the spore. 3. MESOCARPACEAE.

1. DESMIDACEAE.

Taken from Cook's "British Desmids" 1887.

One-celled algae. Cells for the most part compressed, single, segregate or geminate, or a larger number united into a band, or filament; variable in form, usually constricted in the middle, so as to constitute two symmetrical semi-cells.

Sect. A. Leiosporae.
Sect. B. Cosmosporae.

Section A. Leisporae. Zygospores normally smooth.

Genus 1. Closterium.

Fronds elongate, attenuated, not constricted at the middle, the junction of the segments marked by a pale transverse band. Endochromes often arranged in longitudinal fillets, and at each extremity having a ternimal clear space, in which are active granules; empty fronds smooth or with longitudinal striae, never granulated.

1. Fronds tapering, lower margin concave, often inflated in the centre, inclined downwards toward rounded or sub-acute ends, empty fronds without striae.

a. Fronds lunate, curvature considerable.

1. *C. moniliferum.* Ehr. Inf.; 1838. Fronds stout, five or six times as long as broad, lunate, extremities tapering; upper margin convex, lower concave, with a central inflation, ends rounded; large granules conspicuous, in a single longtitudinal series; empty frond colorless, without striae, sutures not evident. Fish pond, Tarleton State College.

2. C. DIANAE. Ehr. Infus.; 1838. Fronds slender, six or eight times as long as broad, crescent shaped, much curved, rapidly attenuated, upper margin very convex, lower very concave, without central inflation, ends sub-acute, with very slight emargination at the upper outward extremity; large granules in a single series; empty frond somewhat straw colored, or faintly reddish, without stiae, suture evident. Zoospores globose, smooth. Club lake, Stephenville.

b. Frond slightly curved, not lunate.

1. *C. striolatum.* Ehr. Abh. Berl. Akad., 1833. Frond from six to ten times as long as broad, lunate, attenuated; upper margin convex, slightly depressed in the centre, lower concave, ends very obtuse, rounded; large granules in a single series; empty frond reddish, especially near the ends, striae very numerous, crowded, transverse sutures usually three. Zygospores orbicular, smooth. Aquarium, Tarleton State College.

Section B. *Cosmosporae.* Zygospore usually warted, spinulose, or ornate.

Genus II. EUASTRUM. Ehr. 1831.

Frond longer than broad, compressed; deeply constricted into two-lobed or sinuated segments, segments usually pyramidal, 5 or 3 lobed or merely sinuous, possessing variously disposed circular inflated protuberances; lateral lobes opposite, very rarely radiant, rounded or sinuated at extremities; end lobes acutely incised or emarginate at the centre, rarely only concave, central constriction linear.

E. verrucosum. Ehr. Abh. Berl. Akad. 1833. Frond somewhat longer than broad, rough all over with conic granules; segments three-lobed, somewhat divergent, all the lobes broad, cunate with a very broad shallow external sinus. Empty frond inflated and verrucose; semi-cells with one large inflation, and a smaller one on each side, two on end lobe. Fish pond, Tarleton State Campus. Plate I, figures 2 and 5.

Genus III. COSMARIUM.

Frond more or less constricted; segments undivided, usually rounded, sometimes slightly sinuated, or rarely slightly contracted, somewhat extended and truncate at the ends, never notched, neither provided with spines nor processes; end view elliptic, and sometimes each side with a lateral opposite inflation, or circular.

1. Margin of segments entire, neither crenulate nor granulate.

1. *C. pseudonitidulum.* Nordst. Norges Desm. 1873. Medium size with habit of C. nitidulum; one fourth part longer than broad, deeply constricted with narrow linear sinus, widened at the extremity; semi-cells somewhat trapezoid, attenuated from the broad base to the rounded truncate apex, lower angles rounded, end view elliptic, side view ovate, circular, membrane punctate. Aquarium, Tarleton State College.

2. Margins of segments crenate or slightly undulate, surface not granulate.

1. *C. undulatum.* Corda. Alm. Carls. 1839. Fronds small, slightly longer than broad; constriction linear; segments semi-orbicular, ends and sides broadly rounded, crenate or minutely undulate at the margin, end view elliptic. Zygospores orbicular, spinous; spines elongate, slender, swollen at the base, and diveded at the apex. Size, length 60 u.; diameter 44 u. (K); diameter 40-44 u. (W); length 54 u.; diameter 39 u. (Wille). Little Paluxy creek.

3. Fronds rough on the surface with pearly granules, which give a denticulate appearance to the margin.

1. *C. reniforme.* Archer in Journ. Bot., 1874. Segments reniform, in end view equally elliptic, zygospores globose, armed with long spines, which are cleft at the summit. Fish Pond, Tarleton State Campus.

Size. Length 50 u.; diameter 50 u.

2. *C. turpini.* Breb. Liste. Desm., 1865. Fronds about as long as broad, constriction deep linear, segments twice as broad as long, somewhat triangular, much inflated and broadly rounded at the base, rapidly attenuated, sides concave, ends truncate, rough all over with scattered pearly granules, and with a central granulated proturberance, end view elliptic, with central, broad truncate proturberances on each side. Aquarium, Tarleton State College.

3. *C. coelatum.* Ralfs. Desm. 1848. Frond in front view about as long as broad, sub-orbicular, constriction deep, linear, segments semi-orbicular, with six broad crenatures at margin, rough at margin with scattered pearly granules, and at the centre with granules somewhat concentrically arranged; end view twice as long as broad, with a broad inflation at each side. Pond on Chandler Farm. Plate I, figure 6.

Size. Diameter 40 u. (Wo.); length 53 u.; diameter 50 u. (C.). Plate I, figure 1.

4. *C. cyclicum.* Lundell Desm. Suec. 1871. Medium size, broader than long; perfectly circular, deeply constricted with a narrow linear sinus; semi-cells semi-circular, margin crenate with 12 crenations, end view narrowly elliptic, side view dilated upwards, with apex somewhat truncate; cell membrane about the margin obsoletely granulate-plicate, with folds arranged in a regular concentric series.

Size. Length 49-52 u.; diameter 52-55 u. (L.). Pond on Chandler Farm.

3. Fronds smooth.

1. *C. moniliforme.* (Turp.) Ralfs. Desm. 1848. Frond minute, in front view twice as long as broad, constriction deep; segments spaerical, smooth; end view circular. Zygospores globose, smooth.

Size. Length 26 u.; diameter 16-21 u. (N.); diameter 16-24 u. (Wo.); length 25-36 u.; diameter 18 u. (D.); zygospore 37 u. (L.). Fish pond, Tarleton State Campus.

2. *C. cymatopleurum.* Nordst. Desm. Spetz. (1872). Large, one third longer than broad, deeply constricted with a narrow linear sinus, broad outwards, semi-cells trapezoid, narrowed upwards from a subreniform base, sides nearly straight, slightly undulated, dorsal margin rounded, truncate, lower angles rounded; end view oval, with transverse granulate folds about each pole; side view elliptically orbicular. Membrane thick, punctate.

Size. Length 85-92 u.; diameter 64 u. (N.); length 82-86 u.; diameter 60-70 u. (N.). Aquarium, Tarleton State College.

Genus IV. Staurastrum. Meyen 1829.

Fronds more or less deeply constricted at the middle; segments broader than long, often provided with spines or processes, end view angular or radiate, or circular, with a lobed radiate margin, or very rarely compressed, with a process at each extremity.

I. Segments with each of the opposite lateral extremities furnished with a bifid or forked spine, its subdivisions subulate-acute, in end view terminating the angles and appearing as a mucro-like spine with or without intermediate spines.

1. S. *bullosum.* Bennett, Roy. Micr. Journ. VI, 1886. Fronds moderately large, semi-cells elliptical, more than twice as broad, triangular in end view united by a narrow isthmus. Each segment with a hemispherical projection, which is very conspicuous, especially in end view. Frond and

9. Cells 30-40 u. diameter. 3. S. VARIANS.
10. Chromatophores 2 or rarely 3. 11.
10. Chromatophores regularly 3 or more. 12.
11. Cells 43-50 u. diameter. 4. S. DUBIA.
12. Spores lenticular. 13.
12. Spores ovoid, ellipsoid, subglobular. 15.
13. Cells less than 100 u. diameter. 14.
14. Fertile cells distinctly swollen. 5. S. BELLIS.
15. Cells 90-100 u. diameter. 16.
15. Cells 80 u. diameter or less. 17.
16. Cells 100-110 u. diameter; chromatophores 4-8. 6. S. SETIFORMIS.
17. Cells 50-80 u. diameter. 18.
18. Cells 50-65 u. diameter. 7. S. TERNATA.
19. Chromatophores single. 20.
20. Spore membrane smooth. 21.
21. Fertile cells little if any swollen. 8. S. WEBERI.
21. Fertile cells distinctly swollen. 22.
22. Filaments 9-23 u. diameter. 23.
22. Filaments 24-33 u. diameter. 25.
23. Inflation rounded or tapering at the ends. 24.
24. Cells 18-21 u. diameter, 10-15 times as long. 9. S. SPREEIANA.
25. Cells 24-40 u. diameter; fertile cells quadrately swollen. 10. S. QUADRATA.
25. Cells 28-33 u. diam., fertile cells somewhat rounded. 11. S. GREVILLEANA.

1. S. *porticalis* (Muller) Cleve, 1868. Filaments 30-48 u. diam., cells 2-6 diam. long; chromatophore single, quite broad, dentate, bright green, making 3-4 turns in the cells; fertile cells little or not at all swollen; spores ovoid or subglobular, yellowish at maturity, 1½ diam. long; diam. up to 42 u. Club lake, Stephenville.

2. S. *condensata* (Vauch) Kutzing, 1843. Filaments 48-54 u. diam., cells as long as broad, or slightly longer or shorter; chromatophores single, slender, with large pyrenoids making ½-1½ turns in the cell; fertile cells not inflated; spores ellipsoid, 1½ diam. long up to 30 u. diam., conjugation usually lateral. Fish pond, Tarleton State College.

3. S. *varians* (Hass) Kutzing 1849. Filaments 33-40 u. diam., cells 2-3 diam. long; chromatophores single, quite broad, dentate or serrate, making 1-3 turns in the cell; fertile cells swollen only on the side of conjugation; cells in filament which have not conjugated often much swollen and distorted; spores ovoid or ellipsoid, 1½-2½ diam. long; diam. 33-38 u. Nine miles east of Stephenville, stream.

4. S. DUBIA Kutzing 1855a. Filaments 43-50 u. diam., cells 1½-2½ diam. long; chromatophores 2, rarely 3, narrow, making 1-3 turns in the cell; fertile cells slightly swollen; spores brownish at maturity, ovoid-ellipsoid, about 40 u. diam., 1-2 diam. long. Drain from Club lake, Stephenville.

5. S. *bellis* (Hass.) Cleve, 1868. Filaments 65-80 u. diam., cells 1½-3 diam. long; chromatophores 5-6, narrow, with large prominent pyrenoids; almost straight, or making half to three quarters of a turn in a cell; fertile

cells swollen and shortened; swelling sometimes only on the side opposite to the conjugation; spores brown at maturity, lenticular, diam. 84-90 u., thickness 55-60 u. Buck farm, creek.

6. S. *setiformis* (Roth) Kutzing, 1845. Filaments 100-110 u. diam., cells about as long as broad, sometimes nearly two diam. long; 4 rather broad chromatophores, irregular, with sinuate margins and many large pyrenois, making ½-1 turn in the cell; fertile cells not swollen; spores ellipsoid, diam. 96-100 u. Little Paluxy creek. Plate II, fig. 1.

7. S. *ternata* Ripart, 1876. Filaments 50-65 u. diam., cells 1½-2 diam. long, somewhat swollen at the middle; chromatophores three, narrow, with apparent middle line uniting the pyrenoids, making 1½-2 turns in the cell; fertile cells swollen and shortened, often shorter than the diameter, so that the spores are turned at right angles to their usual position; spores ovoid, 45-66 u. diam., 1½ diam. Paluxy river.

8. S. *weberi* Kutzing, 1843. Filaments 22-28 u. diam., cells 6-16 diam. long; chromatophore single, slender and loose, with large pyrenoids, making 3½-6 turns in the cell; fertile cells not swollen, or only enough to contain the spores, which are ovoid, 1½-2 diam. long, diam. 26-30 u. Nine miles east of Stephenville.

9. S. *spreeiana* Rabenhorst, 1880. Filaments 18-21 u. diam., cells 10-25 diam. long; chromatophore single, slender, making 1½-4 turns in the cell; fertile cells swollen, not shortened, 30-42 u diam.; spores ellipsoid, yellowish at maturity, 2-3 diam. long, diam. up to 36 u. Burleson farm, small stream.

10. S. *quadrata* (Hass.) Petit, 1847. Filaments 24-27 u. diam., cells 3-9 diam. long; chromatophore single, broad, making 1½-5 turns in the cell; fertile cells much swollen, up to 54 u. diam., appearance like a rectangle with rounded corners; spores ellipsoid or cylindric-ellopsoid, brown at maturity, 1½ to 2 diam. long, diam. 42-48 u. Drain from Club lake, Stephenville.

11. S. *grevilleana* (Hass.) Kutzing, 1849. Filaments 28-33 u. diam., cells 3-10 diam. long; chromatophore broad, usually single but occasionally two in scattered cells, making 4-5, sometimes 6-9 turns in the cell; fertile cells much swollen; spores ovoid with rounded ends, yellowish at maturity, 2-2½ diam. long, diam. 30-36 u. Little Paluxy west of Bluffdale.

Family III. MESOCARPACEAE.

Cylindrical cells, always several times as long as broad, united into unbranched filaments, rarely having short, rhizoidal branches. Chromatophore an axial plate with several pyrenoids; nucleus at the middle of the plate. Conjugation either between two cells of the same plant or of different filaments. Part of the protoplasm separates from the rest in the cell; the part so separating unites with a similar part from the other cell to form the zygospore, which is entirely in the tube connecting the cells, or extends somewhat into one or both cells; spore varying in form, but usually lentiform, with round, or four, or six-angled outline; outer membrane of spore colored yellow or brown, smooth or variously sculptured. Parthenospores, akinetes, and aplanospores sometimes occur, much as in Zygnemaceae.

projection uniformly verrucose, fringed with colorless, equidistant, subulate spines.

Size. Length 85 u.; diameter 38 u. (B). Lily leaf, Thurber Lake.

II. Segments without spines, end view angles rounded.

a. Fronds rough superficially with scattered granules.

1. S. *punctulatum*. Breb. in Ralfs Desm. 1848. Segments rough with puncta like granules, elliptic, equal, end view with broadly rounded angles, and slightly concave sides. Zygospore globose, spines long, rather broad at the base, dichotamous at the apex.

Size. Length 45-50 u.; diameter 38-40 u. (N); diameter 27-36 u. (K.); zygospore 29 u.; spines 14 u. (L.); length 27 u.; diameter 28 u. (D.). Little Paluxy Creek.

Family II. ZYGNEMACEAE.

Filaments sometimes attached, more generally free, all cells except the original basal cell equally capable of division; filaments simple or with short rhizoidal branches, chromatophores of different shapes in different genera; zygospores formed by the union of the contents of two cells, either of the same filament (lateral conjugation), of distinct filaments (scaliform conjugation); formed either in one of the two cells or in the passage way between them. Spores with membranes of three layers, of which the middle layer, mesospore, is the thickest and usually colored brown or yellow in the ripe spore, and often with pits or other markings. In germination the two outer layers are broken, the inner forming the membrane of the new plant, which at once divides into an individual basal cell, and a continuously divisible filament cell.

KEY TO THE GENERA ZYGNEMACEAE

1. Two cells uniting to form one before the formation of the spore. 2.
   2. Chromatophores two, star-shaped. 1. ZYGNEMA.
   2. Chromatophores one or more, parietal, more or less spiral. 2. SPIROGYRA.

1. ZYGNEMA Agardh., 1814.

Cells cylindrical, about as long as broad or somewhat longer; dissepiments smooth and even; two axillary stellate chromatophores in each cell, each with a pyrenoid, the nucleus between the two. Conjugation lateral or scalariform; zygospores formed either in the connecting tube or in one of the cells; spore with median membrane colored, either smooth or pitted; outer membrane colorless, smooth with prominences. Aplanospores formed in unchanged vegetative cells and similar in appearance to zygospores. Akinetes formed from single cells taking on a thick membrane and richer contents; both apalanospores and akinetes exceptional.

KEY TO THE SPECIES OF ZYGNEMA.

1. Spore formed in the tube. Sect. PECTINATA. 2.
1. Spore formed in one of the cells. 4.
   2. Spore without thick lamellate membrane. 3.
3. Spore brownish. 1. Z. PECTINATUM.
   4. Spore with pitted median membrane. sec. Scrobiculata. 5.

5. Spores uniformly globose.
    6. Chromatophores distinct. 2. Z. CRUCIATUM.
    6. Chromatophores indefinite. 3. Z. PURPUREM.
7. Spores usually oblong. 4. Z. STELLINUM.

1. Z. *pectinatum* (Vauch.) Agardh, 1817. Vegetative cells 30-37 u. diameter, 1-3 diameters long; membrance at first thin, later with thick gelatinous sheath; conjugation scalariform; spore globose or broadly ellipsoid, about 50 u. diameter; membrance brown, distinctly pitted. Little Paluxy nine miles east of Stephenville. Plate III, figures 6 and 7.

Var. *anomalum* (Ralfs) Kirchner, 1878. Cells 40-50 u. diameter; membrane very thick. Stream, Buck farm.

2. Z. *cruciatum* (Vauch.) Agardh, 1817. Vegetative cells 35-54 u. diameter, as long or somewhat longer; conjugation scalariform; spores globose, brown, about 40 u. diameter, median membrane finely punctate; fertile cells not swollen. Paluxy River, near Bluffdale.

3. Z. *purpurem*. Wolle, 1887. Diameter of vegetative cells 20-25 u.; cells one or more, rarely two diameters in length. Primarily yellowish green, but soon changes to a dark purple; fruiting filaments more or less geniculated; zygospores more or less spherical; spore-bearing cells slightly or not at all swollen. Little Paluxy, Burleson Farm.

4. Z. *stellinum* (Muller) Agardh, 1824. Vegetative cells 25-36 u. diameter, 1-3 diameters long; conjugation scalariform or lateral; spores ovoid or oblong; 25-48 x 30-35 u., brown, median membrane without pits; fertile cells hardly swollen. Rock Falls.

2. Spirogyra Link, 1820.

Cells cylindrical, one to many times as long as broad; dissepiments either smooth and even with ring-like projections; chromatophores one or more in a cell, in the form of parietal, more or less spirally bent, broad or narrow bands, each containing several pyrenoids; nucleus in the middle of the cell. Conjugation lateral or scalariform; spore formed in one of the two conjugating cells; median membrane colored, smooth or pitted; germinating spore producing a more or less clavate filament.

KEY TO THE SPECIES OF SPIROGRA.

1. Cells emitting a tube. 2.
    2. Dissepiments plane. 3.
    2. Dissepiments replicate. 19.
3. Chromatophores single. 4.
3. Chromatophores two or more. 10.
    4. Spore membrane smooth. 5.
5. Fertile cells not distinctly swollen. 6.
6. Fertile cells distinctly swollen. 8.
    6. Cells 30 u. or more in diameter. 7.
7. Cells 30-48 u. diameter. 1. S. PORTICALIS.
7. Cells 48-70 u. diameter. 2. S. CONDENSATA.
    8. Fertile cells swollen on both sides. 9.

KEY TO THE GENERA OF MESOCARPACEAE

1. Zygospore formed as described for the family; aplanospores exceptional. 1. MOUGEOTIA.

1. MOUGEOTIA Agardh, 1824.

Cells cylindrical, several times as long as broad; dissepiments somewhat lens-shaped; chromatophores an axillary plate with two or more pyrenoids; zygospores formed in the tube, sometimes occupying the whole width of one or both of the original cells; spore with two membranes, the outer colored, smooth or sculptured; akinetes, when occurring, with single membrane, formed by a division of the mother cell into three parts, of which the middle part becomes the akinete.

KEY TO THE SPECIES OF MOUGEOTIA

1. Fertile cells bounded by 2 cells. Sec. MESOCARPICAE.		2.
1. Fertile cell bounded by 4 cells, exceptionally by 2 or 3. Sec. STAUROSPERMICAE.		8.
2. Conjugation scalariform.		3.
2. Conjugation lateral, rarely scalariform.	1.	M. GLENUFLEXA.
3. Spores smooth.		4.
4. Filaments 15 u. diam. or less.	2.	M. PARVULA.
4. Filaments 20 u. diam. or more.		5.
5. Spore occupying more than the length of the tube.		6.
5. Spore occupying the tube only.		9.
6. Spore 45 u. diam. or less.		7.
7. Filaments 20 u. diam. or more.		8.
8. Filaments straight.	3.	M. SPHAEROCARPA.
9. Filaments about 50 u. diam.	4.	M. CRASSA.
10. Spore punctate.	5.	M. QUADANGULATA.

1. *M. glenuflexa* (Dillw.) Agardh, 1824. Filaments 25-33 u. diam., cells 2-5 diam. long, straight or genticulate, in the latter case often uniting with other filaments, but not producing fruit in this way; spores globose or ovoid, smooth, yellowish-brown, usually formed by lateral conjugation, over the dissepiment between the two conjugating cells. Club lake, Stephenville. Plate I, figures 11 and 12.

2. *M. parvula.* Hassall, 1843b. Filaments 6-10 u. diam., cells 5-12 diam. long; spores globose, 8-24 u. diam. occupying the tube and sometimes projecting very slightly into the filaments; membrane brown, smooth. Paluxy river west of Bluffdale.

3. *M. sphaerocarpa.* Wolle, 1887. Filaments 20-25 u. diam., cells 3-6 diam. long; spores spherical, about 40 u. diam., smooth, projecting from the tube into the conjugating cells. Aquarium, Tarleton State College. Plate III, figure 4.

4. *M. crassa* (Wolle) DeToni, 1889. Filaments about 30 u. diam., cells 6-10 diam. long; fertile cells distinctly geniculate; spores 55-50 u. diam., occupying fully the tube, but not projecting into the filaments, spherical. Rock Falls.

5. *M. quadrangulata* Hassal, 1843b. Filaments 8-12 u. diam., cells 6-12 diam. long, fertile cells geniculate; spores quadrangular with truncate or incurved angles in front view, i.e., when placed so that the two filaments are in a plane at right angles to the line of vision; elliptic in form in side view; occupying the width of both filaments; membrane uncolored, pitted. Bosque river. Plate II, figure 13.

2. Gonetonema Wittrock, 1878.

Vegetative cells as in Mougeotia; conjugation unknown; apalanospores with double membrane formed in the middle of an elongated cell, the portions on each side of the spore being shut off by the formation of cross walls.

G. ventricosum Wittrock, 1878. Filaments 5-7 u. diam., somewhat bent geniculately, cells 6-16 diam. long; spores obliquely elliptic, one side being more convex than the other; seen from the side, elliptic, 22-29 x 13-16 u.; 12-15 u. thick, yellowish, smooth. Plate II, figures 3-6.

2. Volvocales

Vegetative cells always motile, or readily passing into a motile stage as vegetative cells, solitary, or united into disk, spherical, or other shape, but not into filaments. Cells uninucleate; chromatospores usually cup-shaped.

1. Cells free, never forming colonies. 1. chlamydomonadaceae.
1. Cells united in colonies. 2.
   2. Colonies of various form, cells motile when free, sometimes when in colonies. 3. tetrasporaceae.
   2. Colonies spherical, ovoid or disk-shaped; cells normally motile. 2. volvocaceae.

1. Chlamydomonadaceae.

Cells free, globose, ovoid, fusiform, or sub-cylindrical, rarely attached by gelatin threads, with 2-4 cilia; chromatophore thick, cup-shaped, sometimes more or less split, with or without one or more pyrenoids; asexual reproduction by zoospores, 2-8 formed in a vegetative cell, and similar to it in form and structure, increasing to the normal size after leaving the mother cell, also by akinetes; sexual reproduction, by gametes, similar to the zoospores, but usually smaller, sometimes 64 in a cell, in some cases with thick membrane; in some cases the male gametes are smaller than the female; by the copulation a spherical zygote is produced, usually red in color. When germinating it becomes green and produces asexual zoospores in the same way as do the vegetative cells.

KEY TO THE GENERA OF CHLAMYDOMONADACEAE.

1. Cells fusiform. 3. chlorogonium.
1. Cells spherical or ovoid. 2.
   2. Protoplasmic threads through the cell wall. 2. haematococcus.
   2. No protoplasmic threads in cell wall. 1 chlamydomonas.

1. chlamydomonas Ehrenberg, 1833. Cells globose, ovoid, or sub-cylindrical, with 2-4 cilia issuing from the same point cell with thin, rather close coating chromatophore with one or more pyrenoids, and usually a red stigma; asexual reproduction by repeated division, usually succeeded by the

loss of cilia, or taking place during a Palmella-stage; sexual reproduction either between similar gametes, or between male and female aplanospores.

C. COMMUNIS Snow, 1903. Cells ovoid, ellipsoid, or cylindrical, 10-13 u. long, 6-8 u. diam.; color light yellowish green; stigma inconspicuous, near anterior end; cilia 2, slightly longer than the cell; pyrenoid near centre; division longitudinal. Fish pond, Tarleton State Campus. Plate II, figure 16.

2. HAEMATOCOCCUS Agargh, 1828.

Cells similar to those of Chlamydomonas but having in the motile stages protoplasmic threads passing through the coating from the central mass to the cell wall; coating usually quite thick, often different in form from the cell itself; cell with or without red stigma, often deep red in color; asexual reproduction by biciliate zoospores produced few in a cell; probable sex reproduction by smaller biciliate gametes, produced many in a cell; but actual conjugation has not been observed.

H. pluvialis Flotow, 1844. Resting cells spherical, 8-80 u. diam., deep red with thick wall; dividing into 4-16 biciliate zoospores, with wide hyaline coating, through which pass very fine, protoplasmic threads; after a short time these spores come to rest, and divide like the parent cell; this may continue for an indefinite number of generations; or at any time the cells may enter into a long resting stage; under certain circumstances the resting spore may divide into 4-32 small, narrowly cylindrical or fusiform spores, probably gametes. Club lake, Stephenville, Texas.

3. CHLOROGNIUM Ehrenberg, 1837.

Cells spindle shaped, with two cilia at the forward end; coating very thin; cells with two or more pyrenoids, a red stigma, and many vacuoles. Asexual reproduction by division into 4 or 8 daughter cells; sexual reproduction by zoogametes formed into 16-32 in a cell, by successive division; copulation taking place between gametes of the same or different sizes, forming a round red zygospore, at whose germination four new individuals are produced, at first red, then green.

C. euchlorum Ehrenberg, 1837. Cells 25-35 u. long, 8 u. diam., with thin wall and two cilia. In quiet water. Aquarium, Tarleton State College. Plate II, figure 17.

Family 2. VOLVOCACEAE.

Motile, biciliate vegetative cells as in Chlaydomonadaceae, but united in families of definite form, mostly spherical or ovoid, continuing motile. Asexual reproduction by the formation of daughter cells, similar to the parent; sexual reproduction varying much in the different genera, from union of similar cells, to fully specialized oogonia and antheridia. Fresh water plants.

1. PANDORINA, Bory, 1824.

Colony globose or subglobose, 8, 16, 32, 64 cells forming a botryoidal mass surrounded by a wide gelatinous coating, cells with close thin membrane, red stigma and two cilia; chromatophore with one pyrenoid. Asexual reproduction by continued division of the cells; sexual reproduction by the union of similar biciliate gametes, produced singly in any cells of the colony; by the union of two such gametes, of the same or different size, a zygote is produced, of reddish color, which after a period of rest produces 1-3 large, biciliate red zoospores; these after a period of rest produce new colonies by vegetative division.

P. MORUM (Hull.) Bory, 1824. Colony globose or ellipsoid, up to 220 u. broad, usually of 16 cells, rarely more or less; cells 9-15 u. diam.; zygote with smooth external membrane. Fish pond, Tarleton State campus, Plate III, fig. 5.

Family 3. TETRASPORACEAE.

Cells normally imbedded in gelatine, in structure like cells of Chlamydomonas, but usually without cilia; dividing vegetatively; asexual reproduction by cells assuming 2 or 4 cilia, escaping from the gelatine, and after a relatively long free existence, coming to rest, and producing a normal colony directly or after a Palmella-stage; sexual reproduction by the division of a cell into several zoogametes, by whose copulation is formed a zygote, germinating at once or after a resting period.

KEY TO THE GENERA OF TETRASPORACEAE

1.	Cells without order in formless gelatine.	1. PALMELLA.
1.	Cells of colony in some definite form and arrangement.	2.
	2. Cells not radially arranged.	3.
3.	Each cell enclosed in a tough elastic membrane.	3. INNEFIGIATA.
3.	Membrane, if any, soft and pliable.	4.
	4. Cells not on definite stalks.	5.
5.	Mature frond an expanded membrane or long filament.	2. TETRASPORA.

1. Palmella Lyngbye, 1819.

Cells spherical, with bell-shaped chromatophore and one pyrenoid, with broad gelatinous, diffluent membrane; asexual reproduction by cell division in all directions, cells separating or joined in small families, forming irregular gelatinous masses; also by akinetes and by ordinary cells developing cilia and becoming motile; sexual reproduction by ciliate gametes.

P. miniata Leiblein, 1830. Cells varying much in size, 3-40 u. diam., colored by haematochrome, orange, brick or blood red, or yellow, solitary or united 2-8, forming irregular gelatinous masses; membrane thick, hyaline, more or less distinctly lamellate. diffluent; sporangia 10-12 u. diam., each producing 4-8 zoospores; or a single cell developing to a baciliate zoospore like form; sexual reproduction by gametes similar to the smaller zoospores. Drain from sewage disposal plant, Stephenville.

2. TETRASPORA Link, 1809.

Colony (frond) gelatinous, membranaceous; saccate, tubular or plain; containing globose cells in a single layer, scattered more or less in 2s and 4s, the thick cell wall diffluent into the general membrane. Asexual reproduction by successive division of cells in the plane of the membrane; also by cells becoming ciliate and motile; they later come to rest and lose their cilia, form a gelatinous membrane, and divide by 2s and 4s; also by akinetes. Sexual reproduction by the conjugation of small biciliate gametes, produced 8 in a cell, the zoospore germinating at once.

KEY TO THE SPECIES OF TETRASPORA.

1. Frond cylindrical only when young if ever. 2.
   2. Frond an irregular inflated sac. 2. *T. gelatinosa*
   2. Frond at first tubular, but soon splitting into irregular segments, often much perforated. 1. *T. lubrica*

1. *T. gelatinosa* (Vauch) Desvaux. Forming inflated bullate masses, not lacunose; very soft and gelatinous; cells 2.5-13 u. diam., very different sizes being found side by side in the same frond. Paluxy river, east of Bluffdale. Plate III, figure 1.

2. *T. lubrica* (Roth) Agardh, 1824. Frond at first attached, tubular or saccate; soon spliting and forming irregular expansions, often with many rounded openings, sometimes quite net-like; up to 20 cm. long and wide, very gelatinous, usually yellowish in color; cells 7-11 u. diam., generally in fours. Bosque river south of Stephenville.

3. INNEFIGATA W. and G. S. West, 1897.

Cells ellipsoid or ovoid, with parietal chromatophore and pyrenoid often colored bright red, united in spherical and sub-spherical families, the cells superficial; each family surrounded by a tough, elastic membrane, with various elastic folds, lobes, processes and spines, the older membrane often including several generations of families; asexual reproduction by cell division, the families separating as they become too large.

1. NEGLECTA W. and G. S. West, 1897. Cells 3-5x6-10 u.; families 20-50 u. diam.; aggregations of successive families up to 350 u. In standing water. Pond on Chandler farm. Plate II, figure 15.

3. Protococcales

Vegetative cells motionless, solitary or in spherical or net-like combinations, rarely filiform. Cells unirarely multinucleate; chromatophore usually single, disk- or cup-shaped.

KEY TO THE FAMILIES OF PROTOCOCCALES

1. Cells free or united in gelatinous colonies. 2.
1. Cells united in regular, net- or disk-shaped colonies, not gelatinous. 3. HYDRODICTYACEAE.
   2. Cells uninucleate, of determinate form. 3.
3. Cells of various form with single chromatophore. 4.
   4. Cells dividing vegetatively. 2. SCENEDESMACEAE.
   4. Vegetative cell division rare and abnormal. 1. PROTOCOCCACEAE.

Family 1. Protococcaceae.

Unicellular, spherical or pyriform, rarely irregular; free or attached; asexual reproduction by zoospores or aplanospores; sexual reproduction by zoogametes in some instances; normal cell division rare and exceptional. Marine or fresh water.

KEY TO THE GENERA OF PROTOCOCCACEAE

1. Cells attached at base or with basal prolongations. 2.
1. Cells without basal attachment or basal prolongation. 3.
 2. Fresh water; chromatophore cup-shaped; one pyrenoid. 2. CHARACIUM.
3. Not endophytic. 4.
 4. Cell membrane smooth. 1. CHLOROCOCCUM.

1. CHLOROCOCCUM Fries, 1825.

Cells spherical with usual thin membrane; chromatophore covering nearly the whole cell wall, with one pyrenoid; asexual reproduction by biciliate zoospores, produced many in a cell.

C. *humicola* (Nag.) Rahenhorst, 1868. Cells varying much in size, 3-25 u. diam., spherical, solitary or united by 2-4; membrane thin, uniform, hyaline. Seepy drain. With Vaucheria in seepy spot near Bosque river.

2. CHARACIUM A. Braun in Kutzing, 1849.

Cells with cup shaped chromatophore and one pyrenoid, from narrowly lanceolate or subcylindrical to broadly ellipsoid or subglobose, often more or less bent, attached by a pointed end or by a stipe like prolongation to the substratum; asexual reproduction by biciliate zoospores of two sizes, escaping by a hole or slit in the cell, also by akinettes; the occurrence of gametes is doubtful.

KEY TO THE SPECIES OF CHARACIUM

1.Not on animals. 2.
 2. With longer or shorter stipe. 3.
3. Stipe without distinct basal disk. 4.
 4 Obtuse. 5.
 4. Acute. 8.
5. Lanceolate to ellipsoid. 6.
 6. Ellipsoid. 7.
7. Stipe extremely short. 1. *C. naegelii.*
 8. Diam. 8 u. or less. 2. *C. ambiguum.*

1. *C. naegelii* A. Braun in Nageli, 1848. Cells 20-42x4-9 u., erect, straight, when young elongate ellipsoid to lanceolate, rather obtuse; when adult, short ellipsoid or ovoid, obtuse; stipe short, without basal disk. On mougeota. Club lake, Stephenville. Plate III, figure 11.

2. *C. ambiguum* Hermann, 1863. Cells 24-32x4-8 u., erect, obliquely and narrowly lanceolate or ensetiform, uniformly attenuate to each end, apex cuspidate, with a sometimes curved apiculum; stipe short, slender, not swollen at the base. Drying pond north of Stephenville. Plate III, figure 10.

Family 2. SCENEDESMACEAE

Unicellular; cells spherical, or developing into various forms, with bell shaped chromatophore, solitary, or united by gelatine into more or less regular colonies; asexual reproduction by aplanospores. Fresh water, rarely marine plants.

KEY TO THE GENERA OF SCENEDESMACEAE

1. Not living in the cells of animals. 2.
 2. Cells contained in an extensive gelatinous thallus. 3.
 2. No external gelatinous thallus. 5.
3. Sporangia not specialized. 4.
 4. Thallus a membrane or mass. 2. SCHIZOCHLAMYS.
5. Mature cell solitary. 6.
5. Mature cells united into colonies. 9.
 6. Mother cell elongate, acicular or fuciforme. 4. RHAPHIDIUM.
 6. Daughter cells formed in the interior of the mother cell. 7.
7. Cells rounded. 8.
 8. Cells spherical. 1. PALMELLOCOCCUS.
9. Cells elongate, side by side in a single or double series. 3. SCENEDESMUS.

1. PALMELLOCOCCUS Chodat, 1843.

Cells free, globose, with wall of two or more layers, with one or more disk shaped chromatophores without pyrenoid, often concealed by an orange red coloring; asexual reproduction by bipartition of the cell, also by division into numerous aplanospores, which escape into a gelatinous vesicle.

1. *P. miniatus* (Leiblein) Chodat, 1894. Cells 3-15 u. diam., orange red, with more or less oil; forming a gelatinous coating on walls of greenhouses, etc. Very generally distributed. Drain from sewage disposal plant.

2. Schizochlamys A. Braun in Kutzing, 1849.

Cells spherical or ellipsoid, irregularly distributed through the colorless gelatine, free floating or attached to water plants; chromatophore filling the cell, without pyrenoid; cell dividing into two daughter cells, the mother cell remaining in two or four pieces about the new cell. Only one species.

S. *gelatinosa* A. Braun, 1849. Forming an irregular mass up to 10 cm. long, pale or yellowish green; cells globose or ellipsoid, 11-14 u. wide, sometimes arranged by two or four. Stream nine miles east of Stephenville.

3. Scenedesmus, Meyen, 1829.

Colonies free, of 2-8 cells, in one row, or in two rows side by side; ovoid or with pointed ends, all smooth or all or part with spines or horns; chromatophore filling the cell, with one pyrenoid; division either by longitudinal walls through each cell, or also by a wall through the length of a colony, dividing each cell across the middle; daughter cells escaping either singly or united into colonies; the free cells often differing considerably in form from the normal colony cells.

KEY TO SPECIES OF SCENEDESMUS

1. Ends of cells obtuse or rounded. 2.
1. Ends of cells acute. 1. *S. obliquus.*
 2. Cells all similar. 2. *S. bijuga.*

1. S. *obliquus* (Turp.) Kutzing, 1833. Colonies of 4-8 cells, cells

fusiform with acute ends, usually in a single series, 5-27x3-9 u. Fish pond, Tarleton State Campus.

2. *S. bijuga* (Turp.) Wittr., Nordst., and Lagerh., Alg. colonies of 4-8 cells; cells oblong-ellipsoid or ovoid, with rounded ends, 7-18x4-7 u., arranged in a single or double row. Fish pond on Tarleton State Campus. Plate I, figure 8.

4. Rhapidium Kutzing, 1845.

Cell elongate, acicular or fusiforme, straight or variously curved, with pointed or rounded ends; chromatophore nearly covering the cell wall, usually without pyrenoid; cell dividing by oblique cross walls into 2-32 daughter cells, which separate soon after attaining their full size and shape; less frequently remaining attached in bundles, or to the wall of the mother cell.

1. *R. falcatum* (Corda) Cook, 1882. Cells bright or yellowish green, fusiform at the middle, sometimes swollen at the middle, sometimes constricted; ends very acute; straight or variously curved. Fish pond, Tarleton State Campus. Plate I, figure 15.

Var. *fusiforme* (Corda) Hansgirg, 1886. Fusiforme, gradually tapering to each end; diam. 2-6 u.; cells 12-20 diam. long, f. clustered. Club lake, Stephenville.

Family 3. HYDRODICTYACEAE.

Cells multinucleate, with net shaped chromatophone, with one or more pyrenoids; united into families of definite form; asexual reproduction by biciliate zoospores, uniting to form a family either in the mother cell, or in a gelatinous vesicle issuing from it; sexual reproduction by gametes escaping from the mother cell, and by copulation forming a resting zygote, from which, by various intermediary stages, the normal vegetative form is produced. Fresh water plants.

1. Pediastrum Meyen, 1829.

Colonies unattached, disk shaped, of round or star-shaped outline, continuous or perforate, composed of marginal cells of different shape to the interior cells; cells multinucleate with net-form parietal chromatophore and one pyrenoid; asexual reproduction by biciliate zoospores, which escape from the cell, enclosed in a vesicular coating, within which they arrange themselves to form a new colony; or by the formation of a new colony in a cell, without intervention of zoospores; sexual reproduction by smaller gametes, more in a cell, copulating to form an irregular Polyedrium-like zygote, within which a new colony is formed, in the same way as in a cell of the mother colony.

KEY TO THE SPECIES OF PEDIASTRUM

1.	Marginal cell bilobed.	2.
	2. Lobes of marginal cells simple.	3.
3.	Disk continuous.	4.
	4. Margin not turbulate crenulate.	5.
5.	Lobes ending in linear teeth.	1. P. Boryanum.

1. BORYANUM (Turp.) Meneghini, 1840. Cells 4-64, rarely 128, 10-20 u. wide, forming a continuous, circular or elliptical disk; disk cells 4-6

angled, the external side varying from prominent to repand; marginal cells more or less emarginate or bilobed, each lobe ending in a longer or shorter terete, obtuse to capitellate projection. Fish pond, Tarleton State Campus. Plate I, figure 7.

4. ULOTRICHALES

Simple or branched filaments, sometimes membranes, rarely in few celled families; cells uninucleate, chromatophones usually single, band-, disk-, net-, or star-shape, generally with one or more pyrenoids. Marine or fresh water.

1. Chromatophores star shaped; zoospores unknown. 2. PRASIOLACEAE.
1. Chromatophores net-, disk-, or band-shaped. 2.
   2. Vegetative cells true green. 3.
3. Fronds unbranched filaments. 4.
3. Fronds branched or membranous, rarely in few-celled families.
   4. Sexual reproduction by isogamous gametes. 1. ULOTRICHACEAE.
   4. Sexual reproduction by oogonia and antheridia. 5.
5. Chromatophores net shaped. 3. OEDOGONIACEAE.
   6. Fronds filamentous, branching, or a few celled family, usually with hairs. 7.
7. Sexual reproduction by isogamous zoogametes. 4. CHAETOPHORACEAE.
7. Sexual reproduction by oogonia and antherida.
   8. Vegetative filaments prostrate.
   8. Vegetative filaments erect. 3. OEDOGONIACEAE.
9. Oospore with cellular envelope; vegetative filaments radiate or united into a disk. 5. COLEOCHEATACEAE.
9. Oospore without cellular envelope; vegetative filaments irregularly spreading. 6. HERPOSTEIRACEAE.

Family 1. ULOTRICHACEAE.

Frond a normally unbranched, uniseriate filament, rarely multiseriate, of uninucleate cells, each of which, with the exception of the basal cell, when present, is capable of producing spores or gametes. Chromatophore either a single, complete, or broken band, or a network, or one of several disks; usually with one or more pyrenoids. Asexual reproduction by bi- or 4-ciliate zoospores, by akinetes, or by aplanospores; sexual reproduction by the conjugation of biciliate zoogametes.

KEY TO THE GENERA OF ULOTRICHACEAE

1. Filaments monosiphonous below, parenchymatous above. 2. SCHIZOMERIS.
1. Filaments monosiphonous throughout. 2.
   2. Cells forming a cylindrical or moniliform filament, without external gelatinous sheath. 3.
3. Without pyrenoid. 3. MICROSPORA.
3. With one or more pyrenoids. 4.
   4. Chromatophore a zonate band, sometimes incomplete. 5.
5. Apical and basal cells little if at all differentiated. 1. ULOTHRIX.

1. ULOTHRIX Kutzing, 1883.

Filaments of a single series of uninucleate cells, all similar, and with the exception of the attached basal cell, capable of division and producing spores. Chromatophores band shaped, with one or more pyrenoids. Asexual reproduction by aplanospores and akinetes, also by 4-ciliate zoospores, with red stigma, formed 1-4 in the cell, germinating immediately; sexual reproduction by biciliate zoogametes formed 8 or more in the cell, germinating after conjugation. External conditions may induce many modifications of the normal process; resting spores may be formed, ultimately producing zoospores; filaments may break up into individual cells, and these by copious formation of gelatine pass into a Palmella or a Gloecystis condition.

KEY TO THE SPECIES OF ULOTHRIX

1.	Fresh water.	2.
	2. Filaments 11-45 u. diam. Pyrenoids several	3.
3.	Mature filaments 25-45 u. diam.	2. U. zonata.
3.	Filaments not over 20 u. diam.	4.
	4. Filaments not torulose.	5.
5.	Cells not over half one diam. long.	
	6. Cells 11 u. diameter.	1. *U. oscillarina.*

1. *U. osillarina* Kutzing, 1845. Forming soft mucilaginous masses; filaments about 11 u. diam.; cells ¼-½ diam. rarely 1 diam.; chromatophore a broad band. Seepy lake shore, Club lake.

2. *U. zonata* (Web. and Mohr) Kutzing, 1833. Forming yellowish green masses; filaments usually 30-40 u. diam., sometimes as low as 11 u. at the base of young filaments, rarely 45 u. in old filaments; cells cylindrical or somewhat swollen, ⅓-1½ diam., long when full grown, longer in young filaments; cell wall at first thin, growing thicker; chromatophore a broad or narrow band at the middle of the cell, with several large pyrenoids. Aquarium, Tarleton State College. Plate I, figure 10.

2. Schizomeris Kutzing, 1843.

Fronds unbranched, filiform, of a single series of cells below, increasing in size above, cells dividing in all directions; reproduction by bicilate zoospores with red stigma; asexual (?). Fresh water.

S. *leibleinii* Kutzing, 1843. Fronds up to 20 cm. high, rather stiff, 20-25 u. diam. at base, up to 150 u. above; terete below, with more or less deep and frequent constrictions above; cells 15-30 u. diam., roundish or angular, with rather thick, often lamellate membrane; zoospores formed in the upper part of the frond, freed by the breaking of the cross walls, the side walls dissolving later; zoospores thus issuing from the summit of the frond. In quiet fresh water. Nine mile bridge on Paluxy. Plate I, fig. 14.

3. MICROSPORA Thuret, 1850.

Filaments simple, usually unattached and with no special basal cell; chromatophore a granular sheet covering the cell wall more or less completely, sometimes with perforations, without pyrenoids, but with scattered starch granules. Cell walls composed of laminae, so arranged that when the filaments break up for the escape of zoospores, the pieces remain in the shape of cylinders open at both ends, with a cross wall near the middle, the so-called "H section." Asexual reproduction by 2- or 4-ciliate zoospores, 1 or 2 in a cell; also by smaller 2-ciliate zoospores, formed several in a cell;

both kinds germinating directly; whether the smaller kind may also act as gametes is uncertain. Aplanospores and akinetes are also formed.

KEY TO THE SPECIES OF MICROSPORA

1.	Cells thick walled.	2.
1.	Cells thin walled.	5.
	2. Cells 16 u. diam. or more.	3.
3.	Cells cylindrical or nearly so.	4.
	4. Cells 21-25 u. diam. long.	1. *M. amoena.*
5.	Cells 11 u. or more.	6.
	6. Cells 14-17 u. diam.	2. *M. floccosa.*

1. *M. amoena* (Kutz.) Rabenhorst, 1868. Filaments long, dark or bright green, nearly cylindrical, 21-25 u. diam.; cells 1-2 diam. long, with walls about 2 u. thick; chromatophores dense, covering the whole cell wall, and hiding the quite large nucleus. In rapid brooks, forming more or less tangled, often quite long masses, April to July. Aquarium.

2. *M. flocca* (Vauch) Thuret, 1850. Filaments bright or yellowish green, cylindrical or nearly so, 14-17 (rarely 18) u. diam.; cells 1½-2 diam. long, with thin walls; chromatophores pale green, often perforated or in net form; akinetes 18-22 u. diam., sphaeroidal, cuboidal, or subcylindrical. Paluxy river west of Bluffdale. Plate III, figures 8 and 9.

Family 2. PRAIOSOLACEAE.

Filamentous or membranaceous; cells with star-shaped chromatophore and one pyrenoid; asexual reproduction by segmentation of the frond, by akinetes and by aplanospheres; sexual reproduction unknown. Fresh water and marine.

1. PRASIOLA (Ag.) Meneghini, 1838.

Fronds membranaceous, monostromatic, attached by short filiform prolongations, by the edge of the membrane, or by a thickened stipe, cells with stellate chromatophore and one pyrenoid, dividing to form groups of fours, these groups forming similar large groups, the spaces between these groups of various orders constituting narrower or wider spaces, running in definite directions through the frond. Asexual reproduction, first by the breaking off of small portions of the frond, which attach themselves and grow independently; second by akinetes formed from individual cells assuming thick walls; these akinetes may develop either directly into a filament or membrane, or indirectly by aplanospores, several in each akinete; third, by aplanospores formed 4-8 in a cell, by walls in two or three directions; sexual reproduction unknown.

1. *P. crispa* (Lightf.) Meneghini, 1838. Fronds of indefinite form, rounded, lacerate, or plicate, without stipe, attached to the substratum by the edge of the frond or by fine fibrils; usually in dense masses; fronds sometimes as much as 10 cm. high or wide, but usually much smaller; generally 13-16 thick; cells squarish or rectangular, 8-13 diam., in cross section square or slightly higher than wide. In moist and unclean places. Water trough at Morgan's Mill. Plate II, figure 10.

2. SCHIZOGONIUM Kutzing, 1843.

Frond normally a filament of a single series of cells, but at times dividing longitudinally, so as to form ribbon shaped fronds, two or a few cells wide; cells usually shorter than their diameter, with central stellate chromatophore and one pyrenoid, asexual reproduction by akinetes and aplanospores.

1. *S. murale* Kutzing, 1843. Forming a soft tomentose stratum, bright or dull green; filaments flexous, simple or rarely with short, few celled branches; cells usually 10-14 u. diam., occasionally a little more or less; often biseriate. On moist earth, rocks, trees, etc.

Family 3. OEDOGONIACEAE.

Frond aquatic, in one European species terrestrial, consisting of simple or branching filaments, of a single series of uninucleate cells; chromatophores generally of many longitudinal bands, with many pyrenoids; cell division by the rupture of a circular ring, which forms the membrane of the new cell. Asexual reproduction by multinucleate zoospores, each produced from the entire contents of the cell, and germinating immediately; also in some cases by akinetes. Sexual reproduction by oogonia and antheridia; oogonia seriate, formed by transformation of vegetative cells; opening by a lid or pore to admit the spermatozoids; when fertilized the oospore assumes a membrane; after a period of rest the oospore produces four zoospores (occasionally fewer or more), which germinate at once. Antheridia either in the same filament with the oogonia or in separate individuals; male plants either of about the same sized cells as the female plants or smaller; in the latter case the male plants rise from androspores, similar to zoospores but smaller; spermatozoids produced one or two in an antheridium, smaller than the androspores, but of a similar appearance. Fresh water.

1. OEGDOGONIUM Link, 1820.

Fronds of single, unbranched series of cells, vegetative cells cylindrical, rarely with constrictions; basal cell with holdfast; terminal cell obtuse, apiculate or produced into a long seta; all cells capable of division; oogonia produced directly by division of the vegetative cell.

KEY TO THE SPECIES OF OEDOGONIUM

1. Macrandrous.	2.
1. Nannandrous.	12.
2. Oogonia opening by a pore.	3.
3. Spores globose.	4.
3. Spores ellipsoid.	8.
4. Pore supramedian.	5.
5. Membrane of oospore smooth.	6.
6. Pore almost superior.	7.
7. Monoecious.	1. *Oe. varians*
8. Oognia manifestly swollen.	9.
9. Membrane of oospore ribbed or pitted.	10.
10. Ribs continuous and entire.	11.

11.	Dioecious.	2. *Oe. boscii*
	12. Dwarf males pluricellular.	13.
13.	Antheridia exterior.	14.
	14. Oogonia opening by a pore.	15.
15.	Oospore ellipsoid.	16.
	16. Pore superior.	17.
17.	Membrane of oospore smooth.	18.
	18. Suffultory cells swollen.	3. *Oe. borisianum*

1. *Oe varians* Wittrock and Lund in Wittrock, 1874. Monoecious; oogonia single, rarely 2, depressed or sub-depressed-pyriform-globose, not filling the oogonium, membrane smoth; antheridia to 9-celled, scattered; spermatozoids binate, division horizontal; basal cell elongate, terminal cell obtuse.

veg. cell,	12-16 u. diam.	3-9 diam. long
oog.,	35-50 u. diam.	35-50 u. long
oos.	31-45 u. diam.	30-41 u. long
anth. cell	11-15 u. diam.	5-7 u. long

Club lake, Stephenville.

2. *Oe. Boscii* (LeCl.) A. Braun, 1855. Dioecious; oogonia single (very rarely double) oblong ellipsoid, pore superior; oospore ellipsoid, not nearly filling the oogonium; marked as in Oe. paludosum; male plant somewhat more slender than the female.

veg. cell, female,	14-23 u. diam.	3-6 diam. long
veg. cell, male,	13-18 u. diam.	4-6 diam. long
oog.	39-51 u. diam.	75-110 u. long
oos.	36-43 u. diam.	56-70 u. long
anth. cell	13-14 u. diam.	6-16 u. long

Pond, Chandler farm.

3. *Oe. borisianum* (LeCl.) Wittrock, 1870. Dioecious, nannandrous, gynandrosporous or idionandrosporous; oogonia single or rarely two or three, oboviform or quadrangular-ellipsoid, not quite filling the oogonium, membrane smooth; suffultory cell swollen; androsporangia 1-7 celled, in the under part of the filament, often superepyginous; basal cell elongate; terminal cell, which may be an oogonium, short apiculate or obtuse, or sometimes produced in a long hyaline seta; dwarf males slightly curved, on suffultory cell; antheridium exterior, 1-2 celled.

veg. cell,	15-23 u. diam.,	3-6 diam. long
suf. cell	31-38 u. diam.	1¾-2½ diam. long
oog.	40-50 u. diam.	55-90 u. long
oos.	35-46 u. diam.	48-60 u. long
Andr. cell	16-19 u. diam.	15-23 u. long
nan. stipe	12-15 u. diam.	37-45 u. long
anth. cell	7-10 u. diam.	11-15 u. long

Thurber lake.

2. Bulbochaete Agardh, 1817.

Filaments branching; vegetative cells increasing in size to upper end; basal cell often lobed, attached to substratum; terminal cell of each filament and branch produced into a long hyaline seta with a bulbous base;

plant increasing mostly by division of cell (basal) of the principal filament or of a branch; oogonia arising by a double division of a vegetative cell.

1. *B. mirabilis* Wittrock, 1870.

Monoecious; oogonia ellipsoid, or oblong ellipsoid, patent or more rarely erect, below terminal seta or vegetative cells; antheridia 1-4 celled, erect or patent, subepyginous or scattered.

veg. cell	15-20 u. diam.	1-1½ diam. long
oog.	26-33 u. diam.	46-58 u. long
anth. cell	9-12 u. diam.	6-9 u. long

Nine mile bridge on Paluxy river east of Stephenville. Plate II, figure 12.

Family 4. CHAETOPHORACEAE

Fronds filamentous, except in a few doubtful forms, usually much branched, sometimes united into disk-like expansions; cells uninucleate, with band- or disk-shaped chromatophores, often somewhat divided or with projections; with one, rarely more pyrenoids; hairs almost always present, but varying in character; asexual reproduction by 4-ciliate, in some cases biciliate zoospores, by aplanospores, akinetes and with special Palmella and Schizomeris stages in many genera; sexual reproduction in many genera by gametes similar to the zoospores.

KEY TO GENERA OF CHAETOPHORACEAE

1. Fronds erect with differentiated base and aspect. 2.
1. Fronds creeping or expanded, no differentiated base and apex. 5.
 2. Fronds more than 1 mm. high, tips generally acute or setiferous. 3.
3. Filaments united into gelatinous thalli of definite form. 2. CHAETOPHORA.
3. Filaments practically free. 4.
 4. Fasciculated ramuli different in character from stem. 3. DRAPARNARLDIA.
 4. Stem, branches and ramuli little differentiated. 4. STIGEOCLONIUM.
5. No dense layer of vertical filaments distinct from the basal layer. 6.
 6. Filaments not united. 7.
7. Cells solitary. 1. DIPLOCHAETE.

In addition to the genera in the foregoing key, there are a few others which may be reduced to rudimentary forms belonging to this family; the cells have the same structure, some species at least produce zoospores and aplanospores, and all have regular vegetative cell division; there seems to be no better place for them.

1. Cells never stalked.
 2. Cells dividing and soon separating, or forming small irregular masses or short filaments. 5. PLEUROCOCCUS.
 2. Cell wall persisting and enclosing walls of later generation. 3.
3. Division in two or three directions. 4.
 4. No opaque bands. 6.
6. Families with no general envelope. 6. GLEOCYSTIS.

1. DIPLOCHAETE Collins, 1901.

Cells solitary or a few united into a gelatinous, sub-filamentous series, globose, flattened, ellipsoid or ovoid, furnished with two or more long, simple, sheathless setae; chromatophore single, parietal (with pyrenoid?). Reproduction unknown.

D. solitaria Collins, 1901. Epiphytic, cells 25-30 u. diam. with walls 5-8 u. thick, little or not at all lamellose; setae two, arising from the lower half of the cell, usually opposite, straight, tapering, 4-6 u. thick at base. Aquarium, Tarleton State College. Plate I, figure 13.

2. CHAETOPHORA Schrank, 1813.

Filaments arising from a palmelloid base, and united by a firm gelatinous substance into thalli or a definite form; filaments repeatedly branched, of about the same diameter throughout, ramuli often in fascicles, frequently terminating in long setae. Chromatophore a parietal band with one or more pyrenoids. Asexual reproduction by biciliate zoospores, formed in the cells of the ramuli; akinetes from any cells.

KEY TO THE SPECIES OF CHAETOPHORA

1. Thalli elongate, lobed and branching.	3. *C. incrassata*
1. Thalli globose or tuberose.	2.
2. Branching loose and spreading.	1. *C. elegans*
2. Branches erect.	3.
3. Branches not fascicled at the summit.	2. C. attenuata.

1. *C. elegans* (Roth) Agardh, 1812. Thalli globose or often tuberculose, up to 1 cm. diam., light green rather soft; filaments radiating from the centre, di-tri-chotomously branched and fascicled above; branches loose and spreading, except sometimes at the tips; ramuli short-pointed or setiferous; cells in main filaments 6-11, usually 8 u. diam., 3-10 diam. long, in ramuli 5-7 u. diam., 1-4 diam. long. Thurber lake.

2. *C. attenuata* Hazen, 1902. Thalli globose or nearly so, not confluent, 2-5 mm. diam., bright green, dense and firm; filaments dichotamously branched, very erect and nearly parallel, not fasciculate; ramuli acute or setiferous; cells of main filaments 5-5.5 u. diam., 5-10 diam. long; of the ramuli about 4 u., rather longer in proportion; branch-bearing cells often broadened and forked at the top; descending rhizoids abundant in the lower part of the frond. Pond, Chandler farm.

3. *C. incrassata* (Huds.) Hazen, 1902. Thalli irregularly extended, lobed lacinate, or branched, main filaments elongate, closely packed in skeins or strands, with alternate or second branches bearing densely fascicled. usually setiferous ramuli; cells of main filaments 8-16 u. diam., 2-6 diam. long, cylindrical or inflated; ramuli often curved, often torulose, 6-11 u. diam., cells 1-2 diam. long, generally distributed. Little Paluxy (creek) west of Bluffdale.

3. DRAPARNARLDIA Bory, 1808.

Filaments united by a soft gelatinous coating, not forming a thallus of definite form; main filaments attached by basal rhizoids, more or less branched, stout, bearing dense lateral fascicles of ramuli, much smaller than the main filaments, often setiferous. Chromatophores in the stem and main branches, a parietal band, sometimes perforated, with numerous pyrenoids; in the cells of the ramuli, a layer covering the wall, with few pyrenoids. Asexual reproduction only from the cells of the ramuli, by 4-ciliate zoospores with red stigma, germinating immediately; also by akinetes and aplanospores; sexual reproduction by conjugation of 4-ciliate gametes, which, however, may germinate without copulation.

D. glomerata (Vauch.) Agardh, 1812. Tufts usually dense, up to 8 cm. long; filaments much branched, branches spreading or horizontal, solitary or opposite, moniloform, bearing very numerous scattered, opposite or whorled fascicles of ramuli; fascicles mostly set at right angles to the stem and sessile, broadly orbicular to elliptical, rachis indistinct, ramuli spreading, crowded, subulate, often longsetiferous; cells of the main branches much swollen, 50-90 or even 125 u. diam., ½-2 diam, long; chromatophores here not over half as broad as the length of the cell, but proportionally broader in the smaller branches; ramuli 6-9 u. diam. Paluxy river nine miles east of Stephenville. Plate III, figures 2 and 3.

4. STIGEOCLONIUM Kutzing, 1843.

Fronds mucilaginous, composed of a branching of filament, without much distinction in character between main filaments and branches; terminal cells pointed or prolonged into a seta: chromatophore prolonged into a parietal band, filling the smaller cells, zonate in the larger. Asexual reproduction by 4-ciliate zoospores with a red stigma; also by akinetes which produce 2 ciliate zoospores, by aplanospores, and also by a palmella stage. Sexual reproduction by conjugation of 2-ciliate gametes with a red stigma.

S. lubricum (Dillw.) Kutzing, 1845. Tufts up to 30 cm. long, dark green, filaments much branched, the branching principally of the opposite type, but often several pairs, single branches or whorls arising from adjacent cells, these cells being subglobose and smaller than other cells in the same ramuli; ramuli, abundant; opposite, scattered, or near the ends of the branches in more or less dense fasscicles; smaller than the branches from which they arise, but only slightly if at all tapering; usually ending in a small point, but sometimes setiferous; lower cells somewhat swollen, 14-17 u. diam, 2/3-2 diam. long, rarely more, with broad, zonate chromatophore; ramuli 6-7 u. diam., cells about as long as broad. Aquarium, Tarleton State College.

5. PLEUROCOCCUS Meneghini, 1842.

Cells rounded or angular by mutual pressure, dividing in all three directions, remaining attached in irregular masses up to 32 cells or even more; chromatophores in the form of small grains or united to a disk, with or without a pyrenoid; zoospores, aplanospores, and zoogametes have been reported.

P. vulgaris Meneghini, 1842. Cells 4-6 u. diam., singly spherical but becoming angular when in contact, often two to many cells continuing attached. On wood, stone, and brick, in moist or shaded places. Broadly scattered.

6. GLOIOCOCCUS A. Braun, 1851.

Cells globose, enclosed in greater or less number, in an ample, globular, transparent, gelatinous mass; with bell-shaped chromatophore and one pyrenoid. Asexual reproduction by division of a cell into four daughter cells, by the formation of aplanospores, and by the formation of biciliate zoospores, of two sizes.

G. mucosus A. Braun, 1851. Cells 6-10 u. diam., colonies 50-1200 u., perfectly spherical and transparent. Common in plankton in fresh water. Aquarium, Tarleton College.

Family 5. COLEOCHAETACEAE

Frond consisting of dichotomously branched, monosiphonous filaments; all prostrate on the substratum, or with erect branches, branches distinct, or laterally united to form a disk, or a pulvinate mass; growth by division of terminal cells only; cells uninucleate, with a parietal chromatophore, covering nearly all of the cell wall, and one pyrenoid, often producing slender, sheathed setae; asexual reproduction by biciliate zoospores; sexual reproduction by oogonia and antheridia, sometimes produced in one individual, sometimes on two.

COLEOCHAETE Brebisson, 1844.

The genus represents the highest type of fructification among the green algae, considerable likeness to some of the mosses. The fronds form bright green disks on fresh water plants or other submerged objects.

1. Forming monostromatic expansions.	2.
2. Filaments more or less distinctly radiate.	3.
3. Filaments laterally united.	4.
4. Disk somewhat irregular in outline; cell usually 25 u. or more.	1. C. SCUTATA.

1. *C. scutata* Brebisson, 1844. Dioecious; frond orbicular subparenchymatous, monostromatic, composed of laterally united, branching filaments, radiating from a centre; cells quadrangular, 25-45 u. diam., 1-3 diam. long; oogonia subglobose, naked below, corticated above, 140-160x120 u.; antheridia produced four from the division of a vegetative cell. Rock in edge of pond.

Family 6. HERPOSTEIRACEAE

Vegetative characters and asexual reproduction as in the Chaetophoraceae; sexual reproduction by antheridia and oogonia transformed from vegetative cells; oogonia spherical, large, with four cilia, which disappear before fertilization by the smaller, pyriform, 4-ciliate spermatozoids. Only one genus.

HERPOSTEIRON Nageli in Kutzing, 1849.

Frond microscopic, epiphytic, composed of simple or irregularly branched filaments; cells bearing on the upper surface long, hyaline, inarticulate setae, with bulbous base, but no sheath; chromatophore parietal, with one or more pyrenoids. Asexual reproduction by 4-ciliate zoospores with red stigma, 1-4 in a cell; sexual reproduction by the union of a spermatozoid and an oospore, both 4-ciliate.

1. *H.* CONFERVICOLA Nageli in Kutzing, 1849. Creeping on fresh water algae, filaments irregularly torulose; cells subglobose to nearly cylindrical; setae more or less frequent, about 3-4 u. diam. at base, very slender above, up to 200 u. long. Lily leaf. Thurber lake.

5. SIPHONOCLADIALES

Fronds multicellular, usually more or less branched; cells multi-, very rarely uninucleate, chromatophores net shaped, or of numerous small disks.

KEY TO THE FAMILIES OF SIPHONOCLADIALES

1. Filaments simple or branched; sexual reproduction isogamous; with main axis of limited growth. 2.
1. With main axis indistinct; all axes of unlimited growth. 3.
    2. Axis bearing whorls of branches of limited growth and of form different from the axis. 2. DASYCLADACEAE.
    2. Zoospores and gametes produced in little changed vegetative cells. 1. CLADOPHORACEAE.

Family 1. CLADOPHORACEAE

Fronds of simple or branching monosiphonous filaments; free or more or less united laterally; cells multirarely uninucleate, with chromatophore net formed, o rbroken into many small portions, with many pyrenoids; asexual reproduction by 4-ciliate zoospores (sometimes biciliate?) and by akinetes; sexual reproduction by biciliate gametes; zoospores and gametes formed in little changed vegetative cells. Marine and fresh water.

KEY TO THE GENERA OF CLADOPHORACEAE

1. Filaments branched. 2.
    2. Branches free, not united to form a membrane or tissue. 3.
3. Branches of successive orders but not of the same character. 4.
    4. Partitions regularly at the bases of the branches. 5.
5. Akinetes formed of swollen intercalary or terminal cells; zoospores unknown. 2. PITHOPHORA.
5. Akinetes unusual, little differentiated; propagation by zoospores. No specialized hooks or rhizoidal branches; cell division chiefly terminal. 1. CLADOPHORA.

1. CLADOPHORA Kutzing, 1843.

Fronds composed of filaments of a single series of cells, the filaments branching, usually abundantly; branching lateral, but often coming to appear dichotamous in consequence of the pushing aside of the original filament by the branch; growth chiefly by division of the apical cell, subsequent division of the cells being rather. exceptional; branches all of the same type; cells multinucleate, the chromatophore either covering the cell wall, or forming a network on it, or in the form of numerous small disks; pyrenoids several in a cell; asexual reproduction by 4-ciliate zoospores; sexual reproduction by bi-ciliate gametes, uniting and germinating independently; also germinating without copulation.

KEY TO THE FRESH WATER SPECIES OF CLADOPHORA

1. Fronds permanently attached.
    2. Ramuli in dense clusters.
3. Ramuli straight or slightly curved.
    4. Lower branches mostly dichotamous; branches connate for some distance. 2. *C. canalicularis*
    4. Branches mostly alternate, branches not connate. 1. *C. glomerata*

1. *C. glomerata* (L) Kutzing, 1845. Fronds up to 30 cm. high, more orlessdensely branched below, branches more and more frequent towards the top, at last forming dense fascicles; filaments cylindrical, 75-100 u. diam. below, 6-7 diam. long; 35-50 u. diam. in the ramuli, 3-6 diam long; ramuli not tapering, tips rounded, fruiting cells terminal or subterminal. Stream, Burleson farm.

2. *C. canalicularis* (Roth) Kutzing, 1845. Fronds 5-10 cm. high, much branched, branching mostly di-trichotomous, branches connate at base; ramuli often fasciculate; main filaments 80-120 u. diam., cells 5-8 diam. long; cells in branches shorter, in ramuli 1-1½ diam. long, 30-50 u. diam., somewhat swollen; cell membrane usually thick. Paluxy river, east of Bluffdale.

2. PITHOPHORA Wittrock, 1877.

Fronds filamentous, monosiphonous, branching, branches issuing from below the top of the cells; cells cylindrical or swollen, multinucleate, with net like chromatophore and many pyrenoids; asexual reproduction by akinetes, terminal or intercalary in the filaments, formed by the division of the vegetative cell, the upper half forming the akinete, the lower half remaining usually sterile; the germinating akinete dividing into two parts, of which one develops a short rhizoid, the other the initial cauloid filament of the future plant.

KEY TO THE SPECIES OF PITHOPHORA

1. Intercalary akinetes all of about the same shape. 2.
1. Intercalary akinetes varying in the same plant; cylindrical, cask-shaped, obvoid or irregular. 2.
    2. Main filament less than 100 u. diam. Special helicoidal cells wanting or rare. 2. *P. oedogonia*
3. Main filament rarely reaching 100 u. diam. 1. *P. varia*

1. *P. varia* Wille. Filaments 75-105 u., primary and secondary branches about the same; terminal cells 43-70 u., rarely ending in helicoids; akinetes 1-3, seriate, with walls, especially the end wall, quite thick, terminal and intercalary, arising in main stem or in branches of any order; terminal akinetes ovoid, with pointed tip, 150-210x64-69 u.; intercalary 70-240x60-112 u.; ovoid, cylindrical or irregular. Pond, Chandler farm. Plate I, figure 4.

2. *P. oedogonia* (Mont) Wittrock, 1877. Main filaments about 70 u. diam., branches of the three orders scattered or opposite; branches occasionally issuing from the short cell below the akinete; akines solitary, rarely in twos, intercalary or terminal; intercalary akinetes cask-shaped about 230-115 u.; terminal akinetes cask shaped, above shortly acuminate, with rounded apex, about 215-95 u. Club lake, Stephenville.

Family 2. DASYCLADACEAE

Fronds consisting of a long, inarticulate axillary cell, attached by rhizoids below, and of whorls of usually pluricellular, simple or branching ramuli of limited growth; in fertile ramuli are produced either gametes, or aplanospores which when freed produce gametes.

KEY TO THE GENERA OF DASYCLADACEAE

1. Frond not calcified. 2.
   2. Sporangia lateral, whorls rather distant. 1. BATHOPHORA.

1. Bathopora J. G. Agardh, 1854.

Vegetative fronds as in Dasycladus; sporangia chiefly lateral, producing aplanospores.

B. oerstedi J. G. Agardh, 1845. Fronds up to 10 cm. high, rather soft and flaccid, 10-13 mm. diam.; whorls distinct, not very close; sporangia ellipsoid to pyriform-subclavate, 500-1000x325-450 u., lateral or occasionally terminal on branches of the first to the fourth orders; aplanospores ellipsoid, 50-70 u. diam., 1½ times as long, in a single layer on the inner surface of the sporangium. Little Paluxy (creek) east of Stephenville. Plate II, figure 11.

6. SIPHONALES

Fronds filiform, usually much branched or developing into various forms, continuous without disepiments in this vegetative condition, multinucleate, with many lens or disk-shaped chromatophores.

KEY TO THE FAMILIES OF SIPHONALES

1. Sexual reproduction by non-motile oospores and motile spermatozoids. 1. VAUCHERIACEAE.

Family 1. VAUCHERIACEAE

Fronds filamentous, cylindrical or with frequent constrictions, with lateral or dichotomous branching; chromatophores small disks, without pyrenoids; asexual reproduction by large, multiciliate zoospores; also by aplanospores and akinetes; sexual reproduction by oogonia and antheridia.

KEY TO THE GENERA OF VAUCHERIACEAE

1. Filaments cylindrical. 1. VAUCHERIA
1. Filaments with frequent constrictions. 2. DICHTOMOSIPHON

VAUCHERIA DeCandole, 1805.

Fronds filamentous, inarticulate, branches arising laterally but often assuming a dichotomous appearance, forming more or less dense tufted or felty masses, usually attached by colorless rhizoids; numerous small chromatophores without pyrenoids, and with minute nuclei. Asexual reproduction by very large zoospores, covered with cilia, with small nucleus corresponding to each pair of cilia; produced in somewhat clavate end of branches, arising similarly to zoospores, but without cilia, germinating only after a longer or shorter period of rest; also in some species by akinetes, the filament breaking up into shorter portions, each with a thick wall. Sexual reproduction by oogonia and antheridia, of quite variable shape and position; usually on the same filament, but in some species on distinct individuals; oogonia sessile or pedicellate, partitioned off from the frond and producing a large globose, or subglobose uninucleate oospore; antheridium similarly located and partitioned off from the frond, producing many biciliate spermatozoids, with cilia pointing in opposing directions; when the oospore is formed, the oogonium dissolves, and the spermatozoids enter, fertilizing the oospore, which germinates after a resting period.

A widely distributed genus of unattractive appearing plants, but interesting by their elaborate and varied fructification. Sterile plants are quite indeterminable, and fruit is not always easy to find; and in dried material or herbarium specimens the fruit is not in as good condition for study as in most other algae.

KEY TO THE SPECIES OF VAUCHERIA

1.	Antheridia not separated from the frond by an empty cell.	2.
	2. Antheridia hooked or circinate.	3.
3.	Oogonia sessile on the main filament or very shortly stipitate.	4.
3.	Oogonia on a branch or distinct pedicel, antheridium terminal.	6.
	4. Oogonia oblique.	5.
5.	Filaments 50-85 u. diam.	1. *V. sessilis*
	6. Oogonia sessile on the branch or nearly so.	2. *V. terrestris.*
	6. Oogonia stipitate usually 2-6.	7.
7.	Pedicels of oogonia and antheridia arising near the end of the branch.	8.
	8. Branch short; anther usually surpassing the oogonia.	3. *V. germinata.*
	8. Branch long; anther not surpassing the oogonia.	4. *V. longipes.*

1. *V. sessilis* (Vauch) DeCandole, 1805. Filaments 50-85 u. diam.; oogonia usually two, sometimes single, sessile, ovoid, or oblong-ovoid, 70-85 x70-100 u., more or less oblique, with short beak; antheridium between the oogonia or beside the single oogonium on a short pedicel, straight, hooked or circinate; ripe oospore dark spotted with triple membrane, filling the oogonium; zoosporangia ovoid-clavate, terminal on a branch which is however sometimes so short that the sporangium appears sessile; zoospores 100-145x110-125 u., with cilia evenly distributed. Paluxy at Bluffdale.

2. *V. terrestris* (Vauch) DeCandole, 1805. Filaments 50-80 u. diam.; oogonia usually solitary, 85-125x60-100 u., lateral on a short branch, on the summit of which is the curved or circinate antheridium, about 20 u. diam.; oospore to plano-convex, with quadruple membrane and numerous brownish spots; the membrane of the oogonium remaining attached to the oospore and falling with it, gelatinizing and ultimately disappearing. Though the antheridium is really terminal, it is often pushed aside by the oogonium, and appears to be lateral, below the oogonium. On moist ground or submerged. Drain from stock trough supplied with running water. Bluffdale.

3. *V. germinata* (Vauch) DeCandole, 1805. Filaments 50-100 u. diam.; oogonia 2, 70-90 u., ellipsoid-hemispherical to convex-concave, shortly stipulate near the end of a short branch; the antheridium between them, cylindrical, hooked or circinate; ripe oospore brown spotted with triple membrane, filling the oogonium; aplanosporangia either on the same frond as the oogonia or on separate individuals, aplanospores 120-200x120-190 u., formed in ovoid sporangia usually terminating in short, lateral branches, freed by the dissolution of the membrane; akinetes formed by the breaking up of portions of the filaments into short thick walled cells whose development varies considerably, according to circumstances. Common in quiet slowly running water. Seepy spot on bank of Bosque.

4. *V. longipes* Collins, 1907. Filaments 80-90 u. diam., oogonia and antheridia borne at the end of a branch one to several mm. long, 30-40 u. diam.; antheridia terminal, cylindrical or slightly tapering, hooked or circinate; oogonia 70-85x35-40 u., ovoid, slightly oblique, 2-4 on a pedicel 20-30 u. diam., 100-150 u. long, arising a little below the antheridium, and usually surpassing it. In brooks and pools. Rock Falls. Plate II, figure 14.

2. Dichotomosiphon Ernst, 1902.

Fronds filamentous, inarticulate, multinucleate, with disk shaped chromatophores without pyrenoid; filaments di-polychotomous, attached below by slender, colorless rhizoids; branches constricted at base to about half their diameter; similar constrictions formed at intervals between the branchings; membrane thickened at the constrictions; often becoming brown; starch accumulations in large quantities throughout the frond. Sexual reproduction by terminal oogonia and antheridia; oospore globose, with triple membrane, germinating after a resting period. Asexual reproduction by akinetes, in the form of tubular swellings at the end of the branches, or oftener on special lateral branches, germinating after a resting period.

The genus differs from Vaucheria by the true dichotamous branching, the peculiar asexual reproduction, the corymbose arrangement of the sexual organs, the presence of starch in large quantity, and the tendency to articulation shown by the constriction.

D. tuberosus (A. Braun) Ernst 1902. Fronds 2-10 cm. long, 40-110 u. diam., usually 70-95 u.; akinetes straight and elongate or clavate and curved, 0.5-5 mm. long, 200-400 u. diam.; antheridium and oogonium corymbosely arranged at the ends of ultimate divisions; antheridia cylindrical and clavate, more or less curved, 130-170x35-50 u.; oogonia globose, dark green, 250-280 u. diam. Little Paluxy, west of Bluffdale. Plate II, figures 7 and 8.

Chara is abundant in the county. It ranged in species as is indicated by the drawings, but no attempt has been made to classify it.

The writer wishes to acknowledge the services of Miss Lena River Lewis and others in making her collecting trips possible, and also the thoughtful cooperation of Dr. Frederick McAllister of the University of Texas in his useful loans of reference material and in his suggestions with reference to this paper.

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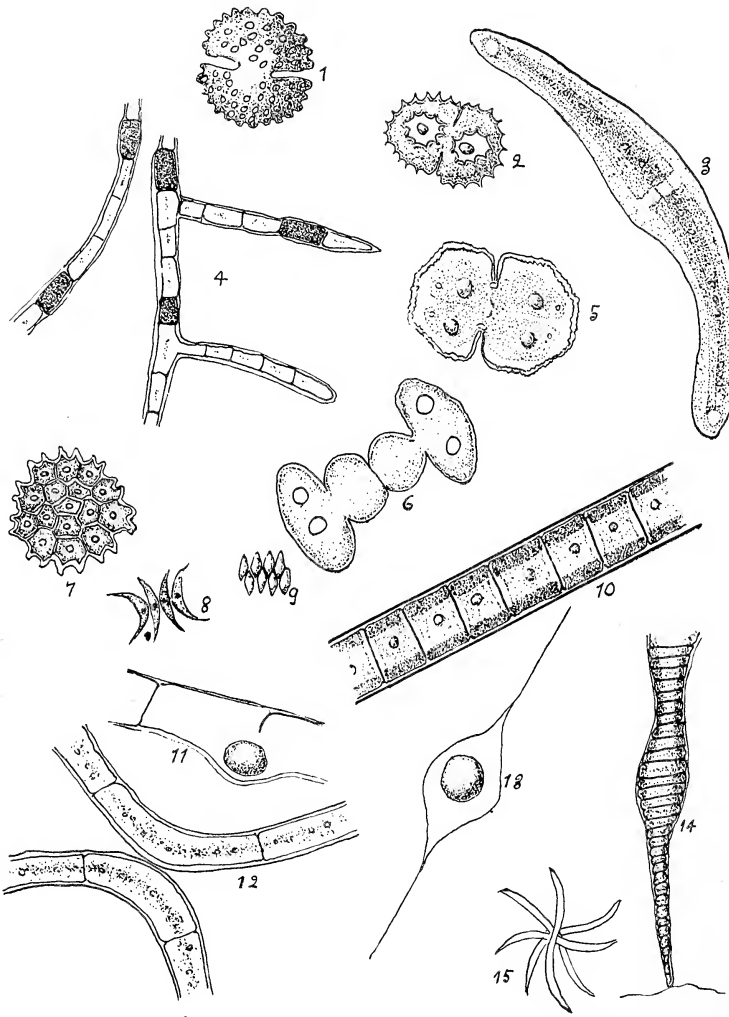

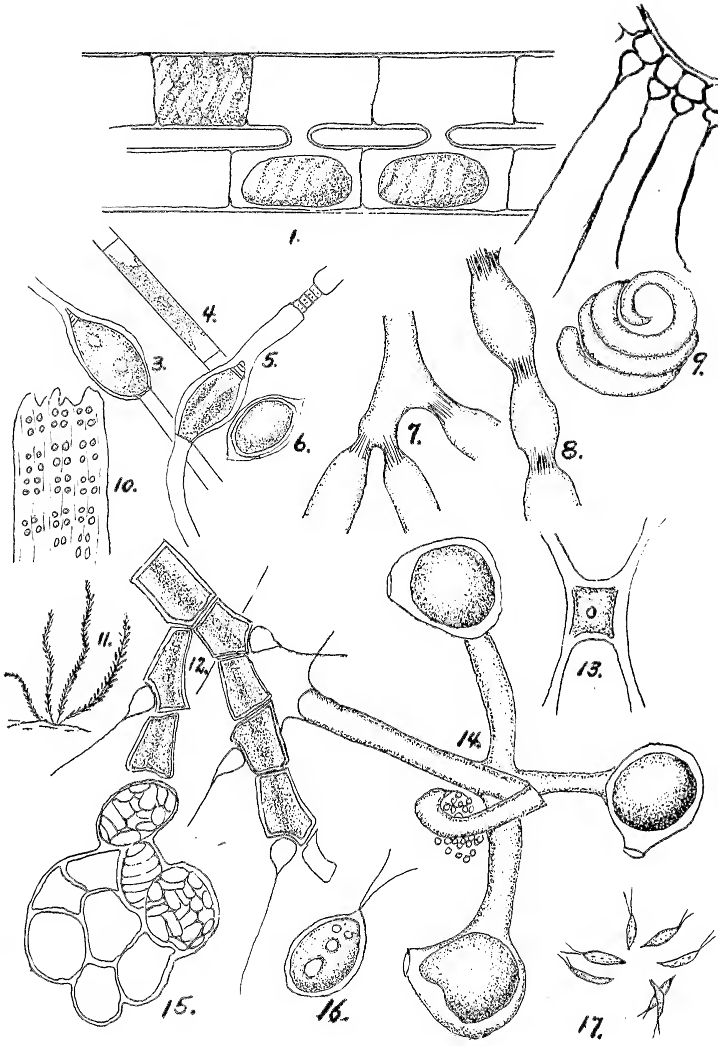
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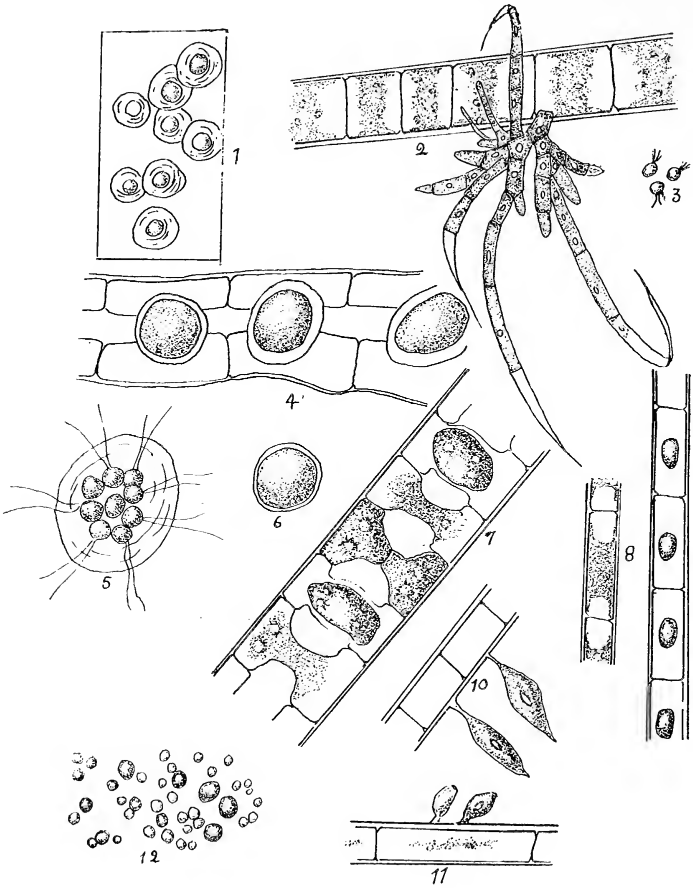

EXPLANATIONS AND REFERENCES

PLATE I

Fig. 1. *Cosmarium logmese* x 440 .... 15.
Fig. 2 & 5. *Euastrum verrucosum* x 440 .... 13.
Fig. 3. *Closterium moniliferum* x 440 .... 12.
Fig. 4. *Pithophora varia* x 440 .... 68.
Fig. 6. *Cosmarium coelatum* x 440 .... 15.
Fig. 7. *Pediastrum boryanum* x 440 .... 44.
Fig. 8. *Scenedesmus bijuga* x 440 .... 42.
Fig. 9. *Scenedesmus obliquus* x 440 .... 42.
Fig. 10. *Ulothrix zonata* x 440 .... 47.
Fig. 11. *Mougeota genufluexa* x 440 .... 28.
Fig. 12. *Mougeota glenuflexa* x 440 .... 28.
Fig. 13. *Diphlochaete scutata* x 440 .... 58.
Fig. 14. *Schizomeris leibleinii* x 100 .... 48.
Fig. 15. *Rhapidium falcatum* var *fusiforme* x 440 .... 42.

EXPLANATIONS AND REFERENCES

PLATE II

EXPLANATIONS AND REFERENCES

PLATE III

THE SUMMER RESIDENT BIRDS OF THE SIERRA VIEJA RANGE IN SOUTHWESTERN TEXAS

Homer W. Phillips and Wilmot A. Thornton
Department of Zoology
University of Texas

INTRODUCTION

A survey of the ecological distribution of the summer resident birds was made in the Sierra Vieja region of Presidio County, Texas, from June 5 to July 9, 1948.

The area studied, and here termed the Sierra Vieja region, lies in the Chihuahuan biotic province as restricted by Dice (1943). Two biotic districts, the Sierra Vieja district and the Rio Grande Basin district, are recognized in our area (York, 1949). Our base camp was in the Sierra Vieja district, on the C. Espy Miller ranch about 11 miles west of Valentine, and most of our collectiong was done there. Four collecting trips were made to an area in the Rio Grande Basin district, about five miles north of Porvenir, for a total of six and a half field days.

Two life belts are recognized in the Sierra Vieja district. The Roughland belt includes the mesas and valleys of the mountain area. The Plains belt takes in the basin or Valentine Plain area. Six ecological associations have been investigated in the Roughland belt and seven in the Plains belt of the Sierra Vieja district. Five associations have been studied in the Rio Grande Basin district, which is not subdivided into life belts. A full description of the associations of the area is presented by York (1949).

Until the time of this brief survey, there had been no ornithological work in the Sierra Vieja Mountains. The list of species which we have recorded in this area is not to be regarded as complete for the summer resident birds. In the Roughland belt we sighted a humming-bird, an owl, and a hawk, which we were unable to collect or identify. In the Rio Grande district we saw one small heron which we also did not identify.

To the east of this area, in Brewster County, the avifauna has been studied by Van Tyne and Sutton (1937). To the north in the Guadalupe Mountains the birds have been studied by Burleigh and Lowery (1940).

John W. Duke Jr. and other members of the field party contributed specimens and information, and we are indebted to them for their assistance. We wish to thank Dr. W. B. Davis of the Texas Agricultural and Mechanical College, who was most considerate in allowing us to use the college collection of skins, and in helping us to identify doubtful species. We also wish to express appreciation to Dr. Josselyn Van Tyne of the Museum of Zoology, the University of Michigan, who kindly examined two specimens of *Piranga rubra cooperi*. We are indebted to Mr. C. Espy Miller for his cooperation in allowing us to collect on his ranch, and in offering suggestions for locating certain species.

To Dr. W. F. Blair, we wish to express our sincere appreciation for his excellent advice and criticism, which made possible the publication of this report.

ECOLOGICAL RELATIONSHIPS

SIERRA VIEJA BIOTIC DISTRICT

This district, as restricted by York, (1949) covers that area of the Sierra Vieja range from the "rim" eastward and the Valentine Plain. It is divided into the Roughland and Plains life belts.

ROUGHLAND LIFE BELT

The Roughland life belt of the Sierra Vieja biotic district includes the mesas and numerous valleys between them, which, taken together, form the Sierra Vieja mountain range. This range of mountains runs in a north-south direction, approximately parallel with the Davis Mountains to the east, and constitutes all of the elevated portions covered by this survey.

Six associations have been described in this belt: the stream bed association, the canyon floors between the mesas from head to mouth; the catclaw-grama association constituting the sloping sides and level areas above the canyon floors; the grama-bluestem association, on the steeper slopes of the canyons; the rock bluff association, restricted to the sheer rock walls of the canyons; the lechuguilla-beargrass association, the majority of the area of the mesa tops, and the lechuguilla-huisache association, which was confined to small areas of the mesa tops.

Twenty-four species of birds of the Sierra Vieja region were found by us to be restricted to the Roughland belt (Table I).

TABLE I

RECORD OF BIRDS IN THE ROUGHLAND LIFE BELT

Numbers indicate the species by associations.
Symbol x indicates the ecological associations in which birds were seen but not collected.

SPECIES RECORDED	RECORDS IN ECOLOGICAL ASSOCIATIONS					
	Stream Bed	Catclaw-Grama	Rock Bluff	Grama-Blue stem	Lechuguilla-Beargrass	Huisache-Lechuguilla
ROUGHLAND BELT SPECIES						
Columba fasciata		x				
Zenaidura macroura	x	x				
Melopelia asiatica	x	x				
Coccyzus americanus	1					
Phalaenoptilus nuttalli					1	
Aeronautes saxatalis			x			
Archilochus alexandri	2					
Dryobates scalaris	7	x				
Sayornis nigricans			3			
Sayornis saya	2					
Tachycineta thalassina	1					
Petrochelidon albifrons	2	1	x			
Baeolophus atricristatus	2					
Auriparus flaviceps	2	3				
Catherpes mexicanus			4			
Salpinctes obsoletus	1				2	
Phainopepla nitens		1				
Vireo belli	4					
Vireo vicinior	2				1	
Molothrus ater	3	2		x		
Guiraca caerulea		1				
Passerina amoena	3					
Passerina versicolor	1					
Spinus psaltria	3					

TABLE I (continued)

SPECIES RECORDED	RECORDS IN ECOLOGICAL ASSOCIATIONS					
	Stream Bed	Catclaw-Grama	Rock Bluff	Grama-Blue stem	Lechuguilla-Beargrass	Huisache-Lechuguilla
WIDE RANGING SPECIES						
Cathartes aura	x	x	1	x	x	x
Buteo jamaicensis	x	x	x	x	x	x
Aquila chrysaetos		x				
Callipepla squamata					x	
Columba fasciata		x				
Bubo virginianus	x	x	1	x	x	
Chordeiles minor	1					
Chordeiles acutipennis	5					
Myiarchus cinerascens	5	3		x	x	x
Corvus cryptoleucus					x	
Heleodytes brunneicapillus		1				
Mimus polyglottos	1	1				
Icterus parisorum	1	1			x	
Piranga rubra	4					
Carpodacus mexicanus	5	1		x	x	x
Pipilo fuscus	2	1			1	
Aimophila ruficeps	4	2	1		x	
Amphispiza bilineata	x	1		x	1	x

Stream Bed Association. Nine species were found to be restricted to this major association of the Roughland belt. Protected, for the most part, by the sheer rock walls on either side, these canyons contained the only free water supply in the belt.

The most characteristic birds in this association were the woodpecker *(Dryobates scalaris)* and the tanager *(Piranga rubra)*.

Twenty-eight of the 42 species recorded from the Roughland belt were collected or observed in this association.

Catclaw-Grama Association. We found none of the 22 species recorded in this association to be solely restricted to it. *Columba fasciata* was observed here on only one occasion. The flycatcher *(Myiarchus cinerascens)* was one of the very common species.

Rock Bluff Association. In this association forming the sheer rock walls of the canyons, we found two species which were evidently restricted, the wren *(Catherpes mexicanus)* and the phoebe *(Sayornis nigricans)*.

Grama-Bluestem Association. This association occurred only on the steep slopes along the sides of the canyons. We observed seven different species in this association, no species being collected.

Lechuguilla-Beargrass Association. There were no species of birds found to be restricted to this association. Two nesting sites of the poorwill *(Phalaenoptilus nuttalli)* were discovered in this area.

Huisache-Lechuguilla Association. The desert sparrow *(Amphispiza bilineata)* was quite common in this association, which formed a relatively small area on the mesa top. No bird species were collected.

PLAINS LIFE BELT

The Plains belt is the second of the two life belts of the Sierra Vieja district. This belt, in contrast to the roughland, forms a broad, wide, sandy area, gently sloping from the alluvial fans along the base of the mountain range out into the level center, or basin area, the Valentine Plain.

Seven associations have been studied in this belt. The tobosa-grama association is the most extensive of these, and occurs throughout the basin area. It is monotonously level and sandy. The mesquite-huisache-blackbrush association occurs in the area around the Burford well, some distance from the mountains. The creosote-bush-catclaw-blackbrush association is found along the lower parts of the alluvial fans in the area around the Roosevelt well. It is limited toward the upper parts of the alluvial fans by the catclaw-tobosa association. The soil is rocky, a typical edaphic feature for all of the fans in this area. The lower areas of this association, end rather abruptly where they meet the tobosa-grama association. The catclaw-tobosa association occurs along most of the upper areas of the alluvial fans right up to the base of the Sierra Vieja range, and takes in all of this rocky area with the exception of the areas around the mouths of some canyons. Here another association has been described, the catclaw-cedar association. This latter association, made up predominantly of scrub cedar, is restricted to areas around the canyon mouths. The yucca-blackbrush-grama association is located near the center of the basin, and is distinguished from the surrounding area by the predominance of yuccas. The blackbrush-creosote-bush association has been described in several localities of the plains. The area around West well near West well canyon is predominantly blackbrush and creosote-bush; another area of this type occurs near the center of the basin and is on a slight rise above the tobosa-grama association which surrounds it.

Thirteen species of birds in the Sierra Vieja region were found by us to be restricted to the Plains belt (Table II).

TABLE II

RECORD OF BIRDS IN THE PLAINS LIFE BELT

Numbers indicate the species by associations.
Symbol x indicates the ecological associations in which birds were seen but not collected.

SPECIES RECORDED	RECORDS IN ECOLOGICAL ASSOCIATIONS						
	Tabosa-Grama	Mesquite-Huisache-Blackbrush	Creosote-Bush Catclaw-black-brush	Catclaw-Tabosa	Catclaw-Cedar	Yucca-Black-brush-Grama	Blackbrush-Creosote-Bush
PLAINS BELT SPECIES							
Buteo swainsoni	x	x	x	x	x	1	x
Oxyechus vociferus	2						
Numenius americanus	1						
Geococcyx californianus				1		1	
Speotyto cunicularia	x						
Muscivora forficata						1	
Otocoris alpestris	2	x	x	x	x	x	2
Toxostoma curvirostre		2					
Lanius ludovicianus	1	x	4			x	
Sturnella magna	2		2				
Cassidix mexicanus				x			
Pyrrhuloxia sinuata		1	2				
Aimophila cassini		2					
WIDE RANGING SPECIES							
Cathartes aura	x	x	x	1	x	x	x
Buteo jamaicensis	x	x	x	x	x	x	x
Callipepla squamata	x	x	x	x	x	x	x
Bubo virginianus	x	1	x	x	x	x	x
Chordeiles minor	1	2					
Chordeiles acutipennis	1						
Myiarchus cinerascens		x	x	x	x		
Corvus cryptoleucus	2						
Heleodytes brunneicapillus		1					
Mimus polyglottos		x					
Icterus parisorum		x	2		x		
Piranga rubra	1						
Carpodacus mexicanus	1	1	1	x	1		x
Piplo fuscus	1				1		
Aimophila ruficeps					x		
Amphispiza bilineata	1	1	x	x	x	x	x
ROUGHLAND SPECIES							
Columba fasciata			1				

Tobosa-Grama Association. Three species were found to be restricted to this area, the killdeer *(Oxyechus vociferus)* the curlew *(Numenius americanus)* and the burrowing owl *(Speotyto cunicularia)*.

The burrowing owl was restricted to prairie dog towns, which we found only in this association. The long-billed curlew cannot be definitely said to be limited to this area, as only one was seen.

Mesquite-Huisache-Blackbrush Association. Rather dense stands of mesquite and huisache formed an ideal haunt for many bird species in this association including the horned owl *(Bubo virginianus)*. The thrasher *(Toxostoma curvirostre)* and the sparrow *(Aimophila cassini)* were apparently limited to this association.

Creosote-Bush-Catclaw-Blackbrush Association. The flycatcher *(Myiarchus cinerascens)* and the cowbird *(Molothrus ater)* were common birds of this area, although no species were found to be restricted here.

Catclaw-Tobosa Association. No species were found to be restricted solely to this association although extensive observation and collecting was not carried on in this area.

Catclaw-Cedar Association. This association, made up predominately of cedar, was restricted to areas around the canyon mouths. The Association formed what may be termed an intermediate zone between the Roughland and the Plains belts. All of the species found in this association ranged in both the Plains and Roughland belts with the exception of the horned lark *(Otocoris alpestris)* which was limited to the Plains belt. There was a scarcity of birds in this area.

Yucca-Blackbrush-Grama Association. The scissor-tailed flycatcher *(Muscivora forficata)* was seen only in this association. Although this species was in no way abundant, it is unlikely that it was restricted to this association.

Blackbrush-Creosote-Bush Association. The horned lark *(Otocoris alpestris)* and the desert sparrow *(Amphispiza bilineata)* were common birds in this association. No species was found to be limited here.

RIO GRANDE BASIN BIOTIC DISTRICT

This district lies to the west of the Sierra Vieja range, and was in past geologic history an extensive basin. It differs from the Sierra Vieja district in that it has a lower altitude and a permanent body of water, the Rio Grande. In accordance with these differences, the vegetation is of a different type also. There is very little tobosa or grama grass in the area, but thin growths of grama grass can be found on the hills of the ocotillo-creosote-bush association. The predominant types of vegetation are thick growths of mesquite and salt cedar along the river banks, and ocotillo and creosote-bushes on the hills and flats further from the river.

Six associations were studied in this area. The mesquite-salt cedar association is found on both sides of the Rio Grande, and is a region of exceptionally dense vegetation. The stream bed association, the stream bed itself, was not described by York (1949). Several species of birds were seen nowhere else, so a stream bed association is here recognized. The old field association was a large cleared area adjacent to the mesquite-salt cedar association; this area was only partly cultivated at the time of this survey. The cottonwood association was also near the river, and consisted chiefly of cottonwood trees, in sharp contrast to the mesquite-salt cedar association which surrounded it. The ocotillo-creosote-bush association was an area of scanty vegetation on the low rocky hills in the basin. The catclaw-creosote-bush association occupies the sandy flats between the hills some distance from the river.

Eight of the 34 species found in the Rio Grande Basin Biotic District were not found in the Sierra Vieja Biotic District (Table III).

Mesquite-Salt Cedar Association. This association contained more bird life than any other association in this district. Of the 34 species found in the district 31 were seen or collected in the mesquite-salt cedar, and 14 species were found to be restricted here. The grackle *(Cassidix mexicanus)* although observed only in this association is in all probability not limited to it in this area. The long-tailed chat *(Icteria virens)*, the mocking bird *(Mimus polyglottos)* and the white-winged dove *(Melopelia asiatica)*, were common birds in this association.

Stream Bed Association. A small heron, unidentified, was observed on a sand bar in the river as was a killdeer *(Oxyechus vociferus)*. These birds were apparently limited to this association, which contained the only available water. Night hawks were commonly seen over the stream bed.

Old Field Association. This association had a very abundant bird population, but apparently no species was restricted to it. The Texas night-hawk *(Chordeiles acutipennis)* the mocking bird *(Mimum polyglottos)*, the silky flycatcher *(Phainopepla nitens)* and the blue grosbeak *(Guiraca caerulea)* were partciularly numerous here.

Cottonwood Association. The white-winged dove *(Melopelia asiatica)*, the house-finch *(Carpodacus mexicanus)* and Harris's hawk *(Parabuteo unicinctus)*, were common here, and several nests of Harris's hawk were found on the cottonwood trees.

Ocotillo-Creosote-Bush Association. Several nests of the white-necked raven *(Corvus cryptoleucus)* were located on rock ledges in this association. The tanger *(Piranga rubra)* was another characteristic bird of this hilly area.

Catclaw-Creosote-Bush Association. In this flat, sandy area the mocking bird *(Mimus polyglottos)* and the house finch *(Carpodacus mexicanus)* were common. We found no species to be restricted here.

ANNOTATED LIST OF SPECIES

Sixty-three species of birds have been recorded from the Sierra Vieja region, including the Rio Grande Basin district. Nine of these species are represented by sight records. A total of 216 specimens was collected. These specimens are now in the Texas Natural History Collection, Department of Zoology, The University of Texas.

Where measurements have been made of the gonads of the breeding

TABLE III

RECORD OF BIRDS IN THE RIO GRANDE BASIN BIOTIC DISTRICT
Numbers indicate the species by associations.
Symbol x indicates the ecological associations in which birds were seen but not collected.

SPECIES RECORDED	RECORDS IN ECOLOGICAL ASSOCIATIONS					
	Mesquite-Salt Cedar	Stream Bed	Cottonwood	Ocotillo-Creosote-Bush	Catclaw-Creosote-Bush	Old Field
Rio Grande Species not found in Sierra Vieja Biotic Dist.						
Ardea herodias	x	1				
Parabuteo unicinctus	x	x	1	x	x	x
Lophortyx gambeli	2	x		x	x	1
Tyrannus verticalis	3					
Pyrocephalus rubinus	1					
Icteria virens	7					
Icterus spurius	1					
Passerina ciris	4					
Wide Ranging Species in Both Biotic Districts.						
Cathartes aura	x	x	x	x	x	x
Buteo jamaicensis	x	x	x	x	x	x
Buteo swainsoni	1	x	x	x	x	x
Oxyechus vociferus		x				
Melopelia asiatica	x	x	x	x	x	x
Coccyzus americanus	x					
Geococcyx californianus	1			1	x	
Chordeiles acutipennis	1	2			1	
Chordeiles (species)						x
Dryobates scalaris	1					
Myiarchus cinerascens	3					x
Corvus cryptoleucus	x	x	x	x	x	x
Auriparus flaviceps	2					
Mimus polyglottos	5				1	x
Phainopepla nitens	2					x
Vireo belli	3					
Vireo vicinior	1					
Icterus parisorum	1					
Cassidix mexicanus	x					
Molothrus ater	3					
Piranga rubra				1		
Pyrrhuloxia sinuata	1					
Guiraca caerulea	4					x
Passerina versicolor	1					
Carpodacus mexicanus	1	x	x	x	x	x
Amphispiza bilineata	1			x		x

birds, the size of the largest testis or ovum was taken in millimeters.

The nomenclature followed is that of the American Ornithologists' Union *Check-list of North American Birds* (1931), with the exception of certain subsequent changes.

Ardea herodias treganzai Court

Treganza's Heron (194c.)

1ad. ♀, breeding condition (2.8 mm), 10 miles northwest of Porvenir, stream bed association, July 2.

An individual of this species was observed on our first trip to the Rio Grande Basin on June 14, in a cottonwood tree in the mesquite-salt cedar association. Our specimen was taken on a subsequent trip to the river. It was in full breeding plumage.

Cathartes aura teter Friedmann (1933)

Turkey Vulture

1 ad. ♀, breeding condition, 11 miles west of Valentine, rock bluff association, June 6; 1 ad. ♂, breeding condition, 11 miles west of Valentine, catclaw-tobosa association, June 23.

These birds are referable to *C. aura teter,* although the one specimen collected by Van Tyne and Sutton (1937) in the Chisos Mountains was identified as *C. aura aura,* the Mexican form of turkey vulture.

The turkey vulture was common throughout the entire area covered by this survey. In the Roughland belt the species roosted on the rock bluffs on either side of the canyons. In the Rio Grande Basin district they were observed roosting in large numbers in the trees bordering the river.

Observations by Mr. C. E. Miller Jr. seem to indicate that this species migrates from the Sierra Vieja Mountains in October. The departure date for the last two years was October 9.

Buteo jamaicensis subsp.

Red-tailed Hawk

Sight Record

This species was seen in the Plains and Roughland belts of the Sierra Vieja district, and in the Rio Grande district, but no specimens were collected.

Buteo swainsoni Bonaparte

Swainson's Hawk (342.)

1. ad. ♂, breeding condition, ten miles northwest of Porvenir, mesquite-salt cedar association, June 15;

1 ad. ♂, breeding condition (11.1 mm), 11 miles west of Valentine, yucca-blackbrush-grama association, June 24.

This species ranged over the Plains belt and the Rio Grande Basin district. It was the hawk most frequently observed in the Plains belt.

On June 23, in the yucca-blackbrush-grama association a nest of this species was found in a yucca, six feet from the ground. It contained one white egg and one nestling which had inch-long primaries, but was otherwise covered with down feathers. No bones or any types of food matter were found in or around the nest.

Several subsequent trips were made to this nest in an effort to collect the parent birds. When the nest was approached the two adults would begin to circle high above it and scream, whether or not they had been on the nest when it was disturbed. The male was collected when the pair dived to within 20 feet of the nest when the yucca was shaken. In an effort to collect the female, a number one steel trap was arranged on yucca stalks tied above the nest out of reach of the young bird, but the female never returned.

The young bird was removed from the nest and cared for in the camp area for the remainder of our stay. It was fed four or five times daily on jackrabbits, lizards and bird bodies from our skinning table. The meat was cut into "bite-size" pieces and offered to the bird by holding it between two fingers. It ate readily from the first, and also seemed to enjoy water when it was offered. The bird was believed to be about a month old when captured, and in the following two weeks virtually all of the juvenal feathers had appeared except for those of the head.

In November, 1948, the bird was still in captivity, and thriving on a horse-meat diet.

Parabuteo unicinctus harrisi (Audubon)

Harris' Hawk (335.)

1 juv. ♀, non-breeding condition, 10 miles northwest of Porvenir, cottonwood association, July 7.

Harris' Hawk was observed only in the Rio Grande district. The cottonwood association in which this species was nesting was located next to the river and contrasted strongly with the prevailing mesquite-salt cedar association.

One immature bird was collected from the edge of a nest 30 feet from the ground in one of the cottonwoods, and a second hawk was seen to fly from the nest. Six other Harris' hawks were soaring in the vicinity of the cottonwood association.

Aquila chrysaetos subsp.

Golden Eagle

Sight Record

The golden eagle was seen by C. E. Miller Jr., attacking a fox *(Urocyon cinereoargenteus)*Q which had been caught in a steel trap. This bird was in the catclaw-grama association of the roughland. There is no record of this species in any of the other associations of the Sierra Vieja district or in the Rio Grande Basin district, but it undoubtedly occurs in others.

Falco species

Falcon

Sight Record

In the Plains belt on July 6, this falcon was found perched on a lone hackberry tree in the yucca-blackbrush-grama association.

Callipepla squamata subsp.
Scaled Quail

Sight Record

These birds were distributed throughout both the Roughland and the Plains belts.

These birds appeared to be breeding throughout the basin area, but they were most frequently seen in the large area covered by the mesquite-huisache-blackbrush and the tobosa-grama association. Although they were most common in the Plains belt, they were not restricted to it, as they were also observed in the stream bed and the lechuguilla-beargrass associations in the Roughland belt.

No specimens were collected at the request of Mr. C. E. Miller. The scaled quails of our region are probably referable to *C. squamata pallida* Brewster.

Lophortyx gambeli gambeli Gambel
Gambel's Quail (295.)

1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, June 6; 1 a. ♂, 10 miles northwest of Porvenir, mesquite-salt cedar association ,July 7.

With the exception of the cottonwood association these birds were distributed throughout the Rio Grande Basin district. They were not abundant in the mesquite-salt cedar association, where our two specimens were collected.

It was the habit of this species to post a cock bird as a sentinel, usually on a dead tree, to guard the covey from danger. His sharp cry of alarm would scatter the birds, and when the danger was past the sentinel would utter a peculiar whistling call to regather the covey.

Pairs were seen perched on trees occasionally.

Although much wilder than the scaled quail seen in the Plains belt, this may have been due in part to long protection of the latter on the C. E. Miller ranch rather than to inherent differences in the behavior of the two species.

Oxyechus vociferus vociferus (Linnaeus)
Killdeer (273.)

1 ad. ♂, non-breeding condition, 11 miles west of Valentine, tobosa-grama association, June 22; 1 ad. ♀, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 8.

In the Plains belt this species was apparently restricted to the one association which contained water at the time of this survey. It is probable that the killdeer is found in other associations in this life belt during periods of abundant rainfall, when ponds are formed throughout the basin area.

In the Rio Grande Basin district these birds were seen along the sand bars of the stream bed association.

Numenius americanus americanus Bechstein
Long-billed Curlew (264.)

1 ad. ♀, breeding condition (1.7 mm), 11 miles west of Valentine, tobosa-grama association, June 24.

This specimen, which was collected in the Plains belt, was the only curlew seen, although Mr. C. E. Miller Jr. has observed them in this area in considerable numbers in past years.

Columba fasciata fasciata Say
Band-tailed Pigeon (312.)

1 ad. ♂, breeding condition (13.3 mm), 11 miles west of Valentine, creosote-catclaw-blackbrush association, June 23.

The specimen collected was the only one seen in the Plains belt. It was perched on top of a catclaw bush in the creosote-bush-catclaw-blackbrush association when found. Normally this species is found at higher elevations, e.g. in the roughland area of this survey, and its presence on the plain is considered unusual.

One other band-tailed pigeon was seen flying over the catclaw-grama association in the Roughland belt.

Examination of the crop of our specimen revealed a large number of reddish sumac berries *(Schmaltzia microphylla)*.

Zenaidura macroura subsp.
Mouring Dove

Sight Record

Mourning doves were seen in both the catclaw-grama and stream bed association of the Roughland belt.

In the last week of June, 1948, a dove was found incubating two eggs in an oak tree, six feet from the ground, in the stream bed of Z-H Canyon, and both eggs hatched within a few days after we first located them.

Melopelia asiatica subsp.
White-winged Dove

Sight Record

The white-winged dove was seen throughout the Rio Grande Basin district, and was most common in the mesquite-salt cedar association. In the Roughland belt of the Sierra Vieja district they were found nesting in the catclaw-grama and stream bed association, and were most common in the latter. This species was more common than the mourning dove in both districts.

Coccyzus americanus americanus (Linnaeus)
Yellow-billed Cuckoo (387.)

1 ad. ♂, breeding condition (14 mm), 11 miles west of Valentine, stream bed association, June 17.

These birds were recorded from the Rio Grande Basin district in the mesquite-salt cedar association, and from the Roughland belt of the Sierra

Vieja district in the stream bed association. They were heard more often than seen in both areas.

Geococcyx californianus (Lesson)

Road-runner (385.)

1 ad. ♀, 11 miles west of Valentine, catclaw-tobosa association, June 5; 1 ad. ♀, 10 miles northwest of Porvenir, ocotillo-creosote-bush association, June 17; 1 juv. ♂, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7; 1 juv. (2-3 days old), eight miles west of Valentine, yucca-blackbrush-grama association, June 25.

Roadrunners were seen throughout the Rio Grande Basin district. In the Plains belt of the Sierra Vieja district they were observed in the yucca-blackbrush-grama and in the catclaw-tobosa associations.

On June 24 a nest was discovered in the yucca-blackbrush-grama association. The nest was three feet from the ground in a koeberlinia bush, and contained five very young birds. The young were practically featherless, and showed a vigorous feeding response when their bills were touched.

We visited the nest again the following day and found one of the adults on the nest. The party was in a jeep, and the bird remained on the nest when we drove to within 10 feet of it. We walked as close as five feet from the bush before the adult bird burst out of the opposite side and ran straight away from us for about 75 yards where it crouched behind a catclaw bush.

One of the young was collected, and examination of its greatly distended stomach revealed a whole lizard *(Holbrookia maniculatas)* almost the size of the bird. A week later the nest was empty.

Bubo virginianus pallescens Stone

Western Horned Owl (375a.)

1 ad. ♂, non-breeding condition ,nine miles southwest of Valentine, mesquite-huisache-blackbrush association, June 28; 1 ad. ♂, non-breeding condition, 11 miles west of Valentine, rock bluff association, June 28.

We found this owl in many of the canyons of the Roughland belt. During the day this species was seen perched on the rock bluffs. On one occasion one was seen on a high ledge facing a cliff in Z-H Canyon, by which means he was effectively camouflaged. Others were discovered in trees on the canyon floors.

A horned owl was also observed in the mesquite-huisache-blackbrush association of the Plains belt. It was perched in a mesquite tree about six feet from the ground. When approached it flew in a straight line away from the observer, two or three feet from the ground, no higher than the surrounding vegetation, for about three hundred yards, where it landed on the ground. When approached a second time it behaved in a similar manner.

Every evening at dusk these owls could be seen flying down the canyons toward the plains area.

Owl pellets found in the mesquite-huisache-blackbrush association contained bones of the western cottontail *(Sylvilagus audubonii)*, and the plains pocket gopher *(Cratogeomys castanops)*, as well as an unidentified bird skull, possibly a goatsucker of some kind.

Pellets taken from the ledge in the rock bluff associations where one of our specimens was collected contained bones of *Neotoma micropus*, the packrat, and one unidentified species of rodent.

Speotyto cunicularia
Burrowing Owl

Sight Record

Several owls of this species were seen in an old prairie dog town in the tobosa-grama association in the Plains belt. A specimen was collected west of Valentine in Jeff Davis County in this same type association.

Phalaenoptilus nuttalli nuttalli (Audubon)
Nuttall's Poor-will (418.)

1 ad. ♀, breeding condition (soft-shelled egg in the oviduct), 11 miles west of Valentine, lechuguilla-beargrass association, June 7.

This species was most frequently heard and seen flying in the canyons of the Roughland belt at dusk.

On June 7, 1948, a specimen was flushed from a rocky area in the lechuguilla-beargrass association of the Roughland belt. It feigned a broken wing and fluttered five or six yards from the spot where it was first noticed, apparently in an effort to distract our attention from its nesting site. After a fruitless search for eggs or young we collected the bird, which on later examination proved to have a large soft-shelled egg in its oviduct.

On June 9, 1948, C. E. Miller Jr. flushed a poor-will from its two eggs which were in a similar area in the same association, but on another mesa. The bird was flushed from the site again on June 11, and two young were found in place of the eggs. The two birds were close together, facing in the same direction, on the bare ground. No shell fragments could be found in the vicinity. The birds were covered with down, and had their eyes shut. They were not touched to observe whether or not they would show a feeding response.

The parent had flown about 10 yards away from the birds when we arrived, and it remained there motionlessly watching us until we left.

Chordeiles minor howelli Oberholster
Howell's Nighthawk (420e.)

1 ad. ♀, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 10; 1 ad. ♀, breeding condition (17 mm), 11 miles west of Valentine, stream bed association, June 11; 1 ad. ♀, breeding condition (2.6 mm), 11 miles west of Valentine, mesquite-huisache-blackbrush association, June 27; 1 ad. ♀, breeding condition (3 mm), nine miles southwest of Valentine, mesquite-huisache-blackbrush association, June 29.

This species was found in both the Plains and Roughland belts. Its range included the entire plains area, although it was most abundant in the stream bed association of the Roughland belt.

Chordeiles acutipennis texensis Lawrence
Texas Nighthawk (421.)

1 ad. ♀, breeding condition, 11 miles west of Valentine, stream bed association, June 10; 1 ad. ♀, breeding condition, 11 miles west of Valentine, stream bed association, June 15; 1 ad. ♀, breeding condition (2.5 mm), 11 miles west of Valentine, tobosa-grama association, June 29; 1 ad. ♀, non-breeding condition, 11 miles west of Valentine, stream bed association, June 14; 1 ad. ♂, 10 miles northwest of Porvenir, stream bed association, June 16; 1 ad. ♂ ,breeding condition (9 mm), 11 miles west of Valentine, stream bed association, June 17; 1 ad. ♀, breeding condition (3.9 mm), 10 miles northwest of Porvenir, stream bed association, June 17; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 26; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, creosote-bush-catclaw association, July 2; 1 ad. ♀, breeding condition (2.4 mm), 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7.

Five of our specimens were collected in the Roughland belt, one in the Plains belt, and the other four were taken in the Rio Grande Basin district.

Nighthawks were extremely common in the mesquite-salt cedar and old field associations in the Rio Grande Basin district. On one trip to this area, on July 2, they were the common species seen; they were flying back and forth over the old field association in broad daylight in such numbers that 30 to 50 were in sight at all times. They were undisturbed by our presence, and flew within 15 feet of us. They were feeding on the exceptionally abundant insect life, made up in large proportion by mosquitoes.

Many of the birds would light momentarily in trees, and then continue feeding. At dusk they were seen swooping low over the river drinking and feeding.

Aeronautes saxatalis saxatalis (Woodhouse)
White-throated Swift (425.)

Sight Record

On June 7, one of these birds was seen flying around a bluff just west of our camp area in the Roughland belt. Two others of this species were seen by Dr. W. F. Blair, one in the same general area, and the other in the stream bed association of lower Z-H Canyon.

Archilochus alexandri (Boucier and Mulsant)
Black-chinned Hummingbird (429.)

2 ad. ♂, breeding condition (2.8 and 2.2 mm), 11 miles west of Valentine, stream bed association, June 27.

This species was positively identified only in the stream bed association of the Roughland belt.

Dryobates scalaris cactophilus Oberholser
Cactus Woodpecker (396b.)

1 ad. ♀, non-breeding condition, 11 miles west of Valentine, stream bed association, June 20; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 17; 1 juv. ♂, non-breeding condition, 11 miles west of Valentine, stream bed association, July 4; 1 ad. ♂, 11 miles west of Valentine, stream bed association, July 5; 1 ad. ♂, breeding condition (5.5 mm), 11 miles west of Valentine, stream bed association, June 30; 1 ad. ♂, breeding condition (3.4 mm), 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8; 1 juv. ♂, 11 miles west of Valentine, stream bed association, June 9; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 26.

Apparently the limiting factor in the local distribution of this species was the absence of wooded areas. In the Roughland belt such areas were primarily in the stream bed association. In the Rio Grande Basin district, the cactus woodpecker was found in the wooded areas of the mesquite-salt cedar association. The range of this species did not extend into the plains area where there were but few trees.

Tyrannus verticalis Say
Arkansas Kingbird (447.)

1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7; 1 ad. ♂, breeding condition (9.5 mm), 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7; 1 ad. ♂, breeding condition (10.2 mm), 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7.

These birds were observed only in the mesquite-salt cedar association of the Rio Grande Basin district, usually in bands of five or six individuals.

Muscivora forficata (Gmelin)
Scissor-tailed Flycatcher (443.)

1 ad. ♂, non-breeding condition, 11 miles west of Valentine, yucca-blackbrush-grama association, June 23.

These birds were seen occasionally throughout the Plains belt, either flying or perched on yucca stalks.

Myiarchus cinerascens cinerascens (Lawrence)
Ash-throated Flycatcher (454.)

1 ad. ♂, 11 miles west of Valentine, stream bed association, June 6; 1 ad. ♂, non-breeding condition, 11 miles west of Valentine, catclaw-grama association, June 11; 1 ad. ♂, 11 miles west of Valentine, catclaw-grama association, June 7; 1 ad. ♂, 11 miles west of Valentine, catclaw-grama association, June 11; 1 ad. ♂, breeding condition (12 mm), 11 miles west of Valentine, stream bed association, June 15; 1 ad. ♂, 11 miles west of Valentine, catclaw-grama association, June 6; 1 ad. ♂, breeding condition (18 mm), 11 miles west of Valentine, stream bed association, June 5; 1 ad. ♂, breeding condition, 10 miles

northwest of Porvenir, mesquite-salt cedar association, July 2; 1 ad. ♂, 10 miles northwest of Porvenir, mesquite-salt cedar association, June 15; 1 ad. ♂, non-breeding condition. 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7; 1 ad. ♂, breeding condition (16 mm), 11 miles west of Valentine, stream bed association, June 16.

We recorded this species in the Rio Grande Basin district ,and in the Plains and Roughland belts. It was most common in the Roughland belt, where it was generally scattered throughout the main associations.

On July 5, two of these flycatchers were seen carrying nesting material, mostly grasses, to a yucca where they were building a nest about eight feet from the ground. The yucca was in the stream bed association of Z-H Canyon. The ash-throat was by far the most abundant flycatcher in both the Roughland and Plains belts.

Sayornis nigricans nigricans (Swainson)
Black Phoebe (458.)

1 juv. ♂, 11 miles west of Valentine, rock bluff association, June 12; 1 juv. ♂, 11 miles west of Valentine, rock bluff association, June 11; 1 ad. ♂, 11 miles west of Valentine, rock bluff association, June 12.

Specimens were collected only in the Roughland belt along the rock bluff association. Wherever pools of water were found in this area there was likely to be a black phoebe perched on the rocky canyon wall nearby, ready to dart out over the water for insects.

Sayornis saya saya (Bonaparte)
Say's Phoebe (457.)

1 juv. ♀, non-breeding condition, 11 miles west of Valentine, stream bed association, June 21; 1 juv. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 14; 1 ad. ♂, 11 miles west of Valentine, rock bluff association, June 11.

The records for this species include only the stream bed and rock bluff assorications of the Roughland belt. The one specimen that was collected from the rock bluff was perched near a small pool of water. The habits of this species were similar to those of the black phoebe.

Pyrocephalus rubinus flammeus van Rossem (1934)
Vermilion Flycatcher

1 ad. ♀, breeding condition, 10 miles north of Porvenir, mesquite-salt cedar association, July 8.

This female was the only bird of this species seen.

Otocoris alpestris leucolaema (Coues)
Desert Horned Lark (474c.)

1 ad. ♀, breeding condition (2.4 mm), 11 miles west of Valentine, tobosa-grama association, June 6; 1 ad. ♂, breeding condition (9.9 mm), 11 miles west of Valentine, blackbrush-creosote-bush associa-

tion, June 18; 1 ad. ♀, breeding condition (2.4 mm), blackbrush-creosote-bush association, June 19; 1 ad. ♀, breeding condition, 11 miles west of of Valentine, tobosa-grama association, June 7.

In the Plains belt these birds were common throughout all of the associations. They were usually observed in groups of five or more foraging on the ground.

Tachycineta thalassina lepida Mearns
Violet-green Swallow (615.)

1 juv. ♂, non-breeding condition, 11 miles west of Valentine, stream bed association, June 19.

Our one specimen was collected in the stream bed association of the Roughland belt. It was collected swooping low over a pool of water in Z-H Canyon. We did not encounter the species elsewhere.

Petrochelidon albifrons tachina Oberholser
Lesser Cliff Swallow (612a.)

1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 14; 1 juv., 11 miles west of Valentine, June 27; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 14.

This species was in the Plains belt as well as in the Roughland belt where all of our specimens were collected.

The nests were built in clusters high on vertical or overhanging cliffs; at one time 17 birds of this species were counted flying about one of these nesting colonies.

Corvus cryptoleucus Couch
White-necked Raven (487.)

1 ad. ♀, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 10; 1 ad. ♀, breedong condition, 11 miles west of Valentine, tobosa-grama association, June 12.

These large birds were abundant in the Plains and Roughland belts, and in the Rio Grande Basin district.

On June 11, a nest containing six light blue eggs was found in a lone hackberry tree in the tobosa-grama association of the Plains belt. The nest, 15 feet from the ground, was built on a four-inch thick foundation of sticks, and was lined with finely divided cedar bark strips to a thickness of one inch. In the same tree there were the stick foundations of four other nests, evidently built in past breeding seasons. One of these was 18 inches deep, and almost as wide, and was probably a combination of several nests built one above the other.

In the Rio Grande Basin ravens were nesting on a rock ledge 50 feet above the ground in the ocotillo-creosote-bush association.

Baeolophus atricristatus subsp.
Titmouse

1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed

association, June 22; 1 ad. ♀, non-breeding condition, 11 miles west of Valentine, stream bed association, June 22.

This species was seen only occasionally in the stream beds of the various canyons in the Roughland belt and was found nowhere else.

We have not had the opportunity to compare this material with the two subspecies *sennetti* and *atricristatus*. Van Tyne and Sutton (1937) found that specimens from Brewster County did not fit in either of these subspecies.

Auriparus flaviceps ornatus (Lawrence)
Verdin

1 ad. ♂, 10 miles northwest of Porvenir, mesquite-salt cedar association, June 5; 1 sex undetermined, 10 miles northwest of Porvenir, mesquite-salt cedar association, June 5; 1 ad. ♂, 11 miles west of Valentine, catclaw-grama association, June 7; 1 ad. ♂, 11 miles west of Valentine, catclaw-cedar association, June 7; 1 ad. ♂, 11 miles west of Valentine, stream bed association, June 7; 1 juv., 11 miles west of Valentine, stream bed association, June 30; 1 ad. ♂, 11 miles west of Valentine, catclaw-grama association, June 6.

This small bird was most common in the stream bed and catclaw-grama associations of the Roughland belt. In the Rio Grande Basin district they were noticed only in the mesquite-salt cedar association.

Of the seven specimens collected, only two have the characteristic adult plumage. One of these is from the catclaw-grama association of the Sierra Vieja district, and the other is from the mesquite-salt cedar association of the Rio Grande Basin district. Our other specimens did not have the bright coloring on the head and at the bend of the wing.

Heleodytes brunneicapillus couesi (Sharpe)
Northern Cactus Wren (713.)

1 ad. ♂, non-breeding condition, nine miles southwest of Valentine, mesquite-huisache-blackbrush association, June 29; 1 ad. ♂, breeding condition (4.7 mm), 11 miles west of Valentine, catclaw-cedar asssociation, June 18; 1 ad. ♂, non-breeding condition, 11 miles west of Valentine, catclaw-grama association, June 30.

In the Plains belt this species ranged throughout most of the associations. Many nests were found in the mesquite-huisache-blackbrush association of the Plains belt, as well as a few in the catclaw-grama association of the Roughland belt. There were usually several nests in each tree that had any at all, but apparently only one was being used for nesting purposes. The necks of most of the nests had been repaired or lengthened since the original building judging from the condition of the material of which they were constructed.

Catherpes mexicanus conspersus Ridgway
Canon Wren (717a.)

1 ad. ♂, breeding condition, 11 miles west of Valentine, rock bluff association, June 11; 1 juv. ♂, non-breeding condition, 11 miles west

of Valentine, rock bluff association, June 9; 1 ad. ♀, breeding condition, 11 miles west of Valentine, rock bluff association, June 9; 1 ad. ♀, non-breeding condition, 11 miles west of Valentine, rock bluff association, June 23.

The wing measurements for our specimens fit in the *conspersus* series as given by Grinnell and Behle (1935). Burleigh and Lowery (1940) regard their specimens collected in the Guadalupe Mountains as *C. m. albifrons*.

The canon wren was restricted to the rock bluff association of the Roughland belt; its liquid notes were heard in the canyons throughout the day.

Salpinctes obsoletus obsoletus (Say)
Common Rock Wren (715.)

1 juv. ♂, non-breeding condition, 11 miles west of Valentine, stream bed association, June 30; 1 ad. ♂, non-breeding condition, 11 miles west of Valentine, lechuguilla-beargrass association, June 21.

These birds were observed on rock outcroppings on the mesas of the Roughland belt, as well as in the stream bed of West Well Canyon. They were nowhere abundant.

Mimus polyglottos leucopterus (Vigors)
Western Mockingbird (703a.)

1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, stream bed association, July 2; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite- salt cedar association, June 15; 1 ad. ♀, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, June 15; 1 ad. ♂, non-breeding condition, 11 miles west of Valentine, catclaw-grama association, June 19; 1 ad. ♂, breeding condition (11 mm), 11 miles west of Valentine, stream bed association, June 16; 1 juv. ♀, non-breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7; 1 juv. ♂, (one to two days old), 10 miles northwest of Porvenir, creosote-bush-catclaw association, July 3.

These birds were seen in the catclaw-grama and stream bed associations of the Roughland belt; in the mesquite-huisache-blackbrush association of the Plains belt, and in the mesquite-salt cedar and creosote-bush-catclaw associations of the Rio Grande Basin district.

The mockingbird was abundant in the mesquite-salt cedar association. One nest was found with young in the creosote-bush-catclaw association of the Rio Grande Basin district.

Toxostoma curvirostre curvirostre (Swainson)
Curve-billed Thrasher (707.)

1 ad. ♂, breeding condition (10.1 mm), 11 miles west of Valentine, mesquite-huisache-blackbrush association, June 28; 1 ad. ♀, breeding condition (3.5 mm), 11 miles west of Valentine, mesquite-huisache-blackbrush association, June 28.

The two birds collected in the Plains belt were the only ones seen of this species.

Phainopepla nitens nitens (Swainson)
Mexican Phainopepla

1 juv. ♂, non-breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 2; 1 ad. ♂, 11 miles west of Valentine, catclaw- grama association, June 6.

These specimens fit the measurements for the series of *P. n. nitens* from Brewster County given by Van Tyne and Sutton (1937).

The phainopepla was most numerous in the Rio Grande Basin district. It was also noted in the Roughland belt of the Sierra Vieja district, but never in appreciable numbers.

Lanius ludovicianus sonoriensis A. H. Miller (1931)
Sonoran Shrike

1 juv. ♂, non-breeding condition, 11 miles west of Valentine, creosote, bush-catclaw-blackbrush association, June 26; 1 juv. ♂, non-breeding condition, 11 miles west of Valentine, tobosa-grama association, June 10; 1 juv. ♀, non-breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 25; 1 ad. ♂, breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 19; 1 ad. ♀, non-breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 26.

Shrikes were seen only in the Plains belt, and there but seldom. On June 25, 1948, Dr. W. F. Blair observed this species feeding around the base of yuccas in the creosote-bush-catclaw-blackbrush association. The bird would work around the base of one yucca and then fly to another and repeat the operation. It was collected, and the stomach contents consisted largely of *Hymenoptera* and *Coleoptera* fragments.

Vireo belli medius Oberholser
Texas Vireo (638b.)

1 ad. ♂, 11 miles west of Valentine, stream bed association, June 7; 1 ad. ♂, 11 miles west of Valentine, stream bed association, July 4; 1 ad. ♂, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 3; 1 juv. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 10; 1 juv. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 22; 1 juv. ♂, non-breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 3.

The Texas vireo was found only in areas where brush was thick. It was a rather common bird of the mesquite-salt cedar association.

Vireo vicinior Coues
Gray Vireo (634.)

1 ad. ♀, 11 miles west of Valentine, stream bed association, June 6;

1 ad. ♀, non-breeding condition, 11 miles west of Valentine, lechuguilla-beargrass association, June 23; 1 ad. ♂, breedong condition, 11 miles west of Valentine, stream bed association, July 6; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 20.

These birds occurred only in the Roughland belt, and like the Texas vireo, were usually seen only where there was a considerable amount of vegetation.

This is the third record of this species in Texas. It has been recorded previously from the Chisos Mountains by Van Tyne and Sutton (1937), and from the Guadalupe Mountains by Burleigh and Lowery (1940).

Icteria virens longicauda Lawrence
Long-tailed Chat (683a.)

1 juv. ♂, non-breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8; 1 juv. —, 10 miles northwest of Porvenir, July 8; 1 ad. ♀, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 2; 1 ad. ♀, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7; 1 ad. ♀, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 2; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, June 16.

The long-tailed chat was restricted to the mesquite-salt cedar association of the Rio Grande Basin district. Here it was very abundant, especially along the ecotone between this association and the stream bed of the Rio Grande.

Sturnella magna lilianae Oberholser
Lillian's Meadowlark

1 ad. ♀, breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 25; 1 ad. ♀, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 9; 1 ad. ♂, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 8; 1 ad. ♂, breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 25.

We found meadowlarks only in the Plains belt, where they were generally distributed.

Icterus spurius (Linnaeus)
Orchard Oriole (506.)

1 ad. ♀, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8.

The specimen collected was the only one of this species seen.

Icterus parisorum Bonaparte
Scott's Oriole (504.)

1 juv. ♂, breeding conditions, 11 miles west of Valentine, catclaw-

grama association, June 27; 1 ad. ♂, breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 23; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8; 1 ad. ♀, breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 22; 1 ad. ♀, breeding condition, 11 miles west of Valentine, stream bed association, June 15.

Scott's oriole occurred in both the Roughland and Plains belt, and in the Rio Grande Basin district. In addition to the association in which specimens were collected, it was seen in the lechuguilla-beargrass association on the highest mesas in the Roughland belt.

It was found in greatest numbers in the creosote-bush-catclaw-blackbrush association, where it traveled in loose flocks of three to six birds.

Cassidix mexicanus subsp.
Grackle

Sight Record

Only one grackle was seen in the Plains belt, near a tank in the blackbrush-creosote-bush association, while none was found in the Roughland belt. Several were seen in the mesquite-salt cedar association of the Rio Grande Basin district.

Molothrus ater obscurus (Gmelin)
Dwarf Cowbird (495a.)

1 juv., 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8; 1 ad. ♀, breeding condition (7.2 mm), 10 miles northwest of Porvenir, mesquite-salt cedar association, July 2; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir. mesquite-salt cedar association, June 16; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 20; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 22; 1 ad. ♂, breeding condition, 11 miles west of Valentine, catclaw-grama association, June 10; 1 ad. ♂, breeding condition (9 mm), 11 miles west of Valentine, stream bed association, June 15.

This species was present in large numbers in the stream bed association of the Roughland belt. Flocks ranged throughout the roughland with the exception of the mesas. Dwarf cowbirds were also present in appreciable numbers in the mesquite-salt cedar association in the Rio Grande Basin district.

Piranga rubra cooperi Ridgway
Cooper's Tanager (610a.)

1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, ocotillo-creosote-bush association, July 2; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 25; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 12; 1 ad. ♂, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7; 1 ad. ♂, non-breeding condition, 11 miles west of Valentine, stream bed association, June 10; 1 juv. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, June

17; 1 juv. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 7; 1 ad. ♀, 14 miles southeast of Porvenir, mesquite-salt cedar association, June 5; 1 ad. ♀, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 16.

This tanager was always seen in the more thickly wooded portions of the canyons in the roughland. It was in the Rio Grande Basin district, and was found in the Plains belt of the Sierra Vieja district.

Pyrrhuloxia sinuata sinuata (Bonaparte)
Arizona Pyrrhuloxia (594.)

1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 2; 1 ad. ♂, breeding condition (9.2 mm), 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 21; 1 ad. ♀, breeding condition (3.9 mm), 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 23; 1 ad. ♀, breeding condition, 11 miles west of Valentine, mesquite-huisache-blackbrush association, June 29.

The pyrrhuloxia was found in the Plains belt and in the Rio Grande Basin district only. In the latter it was restricted to one association, the mesquite-salt cedar, while in the former, it was found in two associations.

Guiraca caerulea interfusa Dwight and Griscom
Western Blue Grosbeak (507a.)

1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 14; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 16; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 17; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, July 6; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 2; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite- salt cedar association, July 7; 1 ad. ♂, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7; 1 ad. ♀, breeding condition (1.9 mm), 11 miles west of Valentine, stream bed association, June 20; 1 ad. ♀, breeding condition (3.4 mm), 11 miles west of Valentine, catclaw-grama association, June 20; 1 ad. ♀, non-breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8.

This species was recorded in the old field and mesquite-salt cedar associations of the Rio Grande Basin district, and was most numerous along the river itself. It was also quite abundant in the wooded portions of the stream beds of the Roughland belt in the Sierra Vieja district.

Passerina amoena (Say)
Lazuli Bunting (599.)

1 ad. ♀, 11 miles west of Valentine, stream bed association, July 5; 1 ad. ♀, 11 miles west of Valentine, stream bed association, June 30; 1 ad. ♀, 11 miles west of Valentine, stream bed association, June 23.

This species was seen only in the stream beds of the Roughland belt.

Passerina versicolor versicolor Bonaparte

Varied Bunting (600.)

1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 7; 1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 2.

The two buntings of this species which we collected were the only ones seen; one from the Roughland belt of the Sierra Vieja district, and the other from the Rio Grande Basin district.

Passerina ciris (Linnaeus)

Painted Bunting (601.)

1 ad. ♂, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 2; 1 ad. ♂, non-breeding condition, 10 miles northwest of Valentine, mesquite-salt cedar association, July 3; 1 ad. ♀, breeding condition, 10 miles northwest of Porvenir, mesquite, salt cedar association, July 8; 1 ad. ♀, breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 8.

Van Tyne and Sutton (1937) recognize *P. c. pallidior* Mearns for the painted bunting of Brewster County. If this race is to be accepted our material would also be called *pallidior*.

The painted bunting was evidently limited to the thickest part of the mesquite-salt cedar association in the Rio Grande Basin district. It was not seen or heard elsewhere.

Carpodacus mexicanus frontalis (Say)

Common House Finch (519.)

1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 16; 1 ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 20; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 15; 1 ad. ♂, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 8; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 20; 1 ad. ♂, breeding condition, 11 miles west of Valentine, catclaw-cedar association, June 14; 1 ad. ♀, 11 miles west of Valentine, catclaw-grama association June 6; 1 ad. ♀, non-breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 22; 1 ad. ♀, breeding condition, 11 miles west of Valentine, stream bed association, June 19; 1 ad. ♀, non-breeding condition, 10 miles northwest of Porvenir, stream bed association, July 3.

The house finch was perhaps the most abundant bird in the Roughland belt, and it was also present in large numbers in the Plains belt, and Rio Grande Basin district. This species was particularly abundant in shady canyons during the heat of the afternoon. They frequently traveled in pairs or larger groups.

Spinus psaltria psaltria (Say)
Arkansas Goldfinch (530.)

1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, July 5; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 27; 1 ad. ♀, non-breeding condition, 11 miles west of Valentine, stream bed association, June 22.

This species was infrequently seen, and then only in trees in stream beds of the Roughland belt.

Pipilo fuscus texanus van Rossem (1934)
Cañon Towhee (591.)

1 ad. ♂, breeding condition, 11 miles west of Valentine, lechuguilla-beargrass association, June 23; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 15; 1 ad. ♂, breeding condition, 11 miles west of Valentine, catclaw-grama association, June 29; 1 ad. ♂, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 8; 1 ad. ♀, breeding condition, 11 miles west of Valentine, stream bed association, June 15; 1 ad. ♀, non-breeding condition, 11 miles west of Valentine, catclaw-cedar association, June 14.

The cañon towhee ranged throughout the Plains and Roughland belts, from the highest mesas of the roughland down to the plain, however, it was most common in the stream beds of roughland, particularly in Knox Canyon. The birds would run under rocks rather than fly when pursued.

Aimophila ruficeps tenuirostra Burleigh and Lowery
Guadalupe Mountain Rock Sparrow

1 ad. ♂, breeding condition, 11 miles west of Valentine, rock bluff association, June 12; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 22; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 18; 1 ad. ♂, 11 miles west of Valentine, catclaw-grama association, June 7; 1 ad. ♂, 11 miles west of Valentine, catclaw, grama association, June 6; 1 ad. ♂, breeding condition, 11 miles west of Valentine, stream bed association, June 15; 1 ad. ♀, breedong condition, 11 miles west of Valentine, stream bed association, June 23.

Our specimens conform to the description of *A. r. tenuirostra* as given by Burleigh and Lowery (1939).

This sparrow was limited to the Roughland and Plains belts; it was found nesting from the lechuguilla-beargrass association of the mesas to the catclaw-cedar association of the Plains belt.

On June 23 one of these sparrows was flushed from its nest in the lechuguilla-beargrass association. The bird fluttered about 10 feet from the nest feigning an injury in an attempt to distract us. Nests of this species were found in the catclaw-cedar association near the middle of June, some of which contained two eggs. This species was abundant in the stream beds of the Roughland belt.

Aimophila cassini (Woodhouse)
Cassin's Sparrow (578.)

1 ad. ♂, breeding condition (4.6 mm), nine miles southwest of Valentine, mesquite-huisache-blackbrush association, June 28; 1 ad. ♂, breeding condition, nine miles southwest of Valentine, mesquite-blackbrush association, June 29.

This sparrow was seen only in the one Plains belt association in which it was collected.

Amphispiza bilineata opuntia Burleigh and Lowery
Frijole Desert Sparrow

1 ad. ♂, breeding condition (7.6 mm), nine miles southwest of Valentine, mesquite-huisache-blackbrush association, June 28; 1 ad. ♂, 11 miles west of Valentine, lechuguilla-beargrass association, June 7; 1 ad. ♂, breeding condition, 11 miles west of Valentine, tobosa-grama association, June 8; 1 ad. ♂, non-breeding condition, 11 miles west of Valentine, creosote-bush-catclaw-blackbrush association, June 21; 1 ad. ♂, non-breeding condition, 11 miles west of Valentine, catclaw-grama association, June 7; 1 ad. ♀, non-breeding condition, 10 miles northwest of Porvenir, mesquite-salt cedar association, July 7.

Our specimens conform to the description of *Opuntia* as described by Burleigh and Lowery (1939).

The desert sparrow was the most common bird in the Roughland and Plain belts. It was present in every association of the two belts, and was everywhere abundant with the exception of the rock bluff association. It was present in the Rio Grande Basin district, but was not widespread there. In this area it was noted in the old field and ocotillo-creosote-bush associations, and was most abundant in the latter. It was not seen in the mesquite-salt cedar association.

FAUNAL AND BIOGEOGRAPHIC RELATIONS OF THE BIRDS

The birds of the Sierra Vieja region including the Rio Grande Basin district represent three major faunal elements. Twenty-seven of the 63 species are wide-ranging forms that occur throughout much of North America, and occur in many biotic provinces. These species include:

Ardea herodias
Cathartes aura
Buteo jamaicensis
Parabuteo unicinctus
Aquila chrysaetos
Falco species
Oxyechus vociferus
Zenaidura macroura
Coccyzus americanus
Bubo virginianus
Speotyto cunicularia
Chordeiles minor
Otocoris alpestris
Petrochelidon albifrons
Mimus polyglottos
Lanius ludovicianus
Vireo belli
Icteria virens
Sturnella magna
Icterus spurius
Cassidix mexicanus
Molothrus ater
Piranga rubra
Guiraca caerulea

Muscivora forficata
Sayornis saya
Passerina ciris

Thirteen species have their centers of distribution in Mexico, and range into our region from the south. These include:

Lophortyx gambeli
Melopelia asiatica
Dryobates scalaris
Pyrocephalus rubinus
Corvus cryptoleucus
Baeolophus atricristatus
Heleodytes brunneicapillus
Toxostoma curvirostre
Vireo vicinior
Icterus parisorum
Pyrrhuloxia sinuata
Passerina versicolor
Spinus psaltria

Twenty-three species range widely in the western part of North America and occur there in several biotic provinces. These include:

Buteo swainsoni
Callipepla squamata
Numenius americanus
Columba fasciata
Geococcyx californianus
Chordeiles acutipennis
Phalaenoptilus nuttalli
Aeronautes saxatalis
Archilochus alexandri
Tyrannus verticalis
Myiarchus cinerascens
Sayornis nigricans
Tachycineta thalassina
Auriparus flaviceps
Catherpes mexicanus
Salpinctus obsoletus
Phainopepla nitens
Passerina amoena
Carpodacus mexicanus
Pipilo fuscus
Aimophila ruficeps
Aimophila cassini
Amphispiza bilineata

Faunal affinities of the birds of this district may be summarized as follows: 27 species (42.9%) widely distributed, 13 species (20.6%) Mexican, 24 species (36.5%) wide ranging in western North America.

Ornithological field work has been done in two other nearby areas of Trans-Pecos Texas. Approximately 100 miles to the north of the Sierra Vieja range, in the Navahonian biotic province as limited by Dice (1943), work was carried out by Burleigh and Lowery (1940) at intervals during 1938 and 1939. To the east of the area of our survey, Van Tyne and Sutton (1937) did field work throughout Brewster County in 1928, 1932, 1933, and 1935.

Forty-six (54.1%) of the 85 breeding birds found by Burleigh and Lowery in the Guadalupe Mountains were not recorded in the survey of the Sierra Vieja range. Of these 46 species all but 18 (39.1%) occurred at altitudes higher than those of the Sierra Vieja Mountains, the highest peak of which is 6,467 feet.

Greater elevation of the Guadalupe Mountains seems to be primarily responsible for the fact that 54.1% of the breeding birds found by Burleigh and Lowery (1940) were not recorded in the Sierra Vieja range. The Guadalupes reach a maximum elevation of 8,000 feet and consequently have a number of ecological associations not present in the much lower Sierra Viejas. The Guadalupes are included by Dice (1943) in the Navahonian biotic province.

Fourteen species (22.2%) of the 63 recorded from the Sierra Vieja range were not found in the Guadalupe Mountains by Burleigh and Lowery (1940). Three species (4.7%) of the 63 recorded from the Sierra Vieja range were not included in the survey of Brewster County by Van Tyne and Sutton (1937).

We failed to find 55 (46.6%) of the 118 species of birds that appear from Van Tyne's and Sutton's (1937) discussion to breed in Brewster County. These authors listed as breeding and probably breeding a total of 118 species. Several of these birds occurred at higher altitudes than 4500 feet, at which altitude most of our field work was done. It is probable that additional field work in the Sierra Vieja range would reveal other species of breeding birds.

SUMMARY

A survey of the ecological distribution of the summer resident birds was made in the Sierra Vieja region of Presidio County, Texas, from June 5 to July 9, 1948. Sixty-three species of birds were recorded in the Sierra Vieja region. Fifty-four species (216 specimens) were collected. Nine additional species were recorded on the basis of sight records.

Twenty-four species of birds in the Sierra Vieja biotic district appear to be restricted to the Roughland life belt, which includes the mountain mass above 4500 feet. Thirteen species are apparently limited to the Plains life belt, which occurs on the Valentine plain below 4500 feet. The Rio Grande Basin biotic district to the west of the Sierra Vieja range, differs markedly from the Sierra Vieja district in altitude, vegetation, and amount of water present. Eight (24.2%) of the 33 species seen or collected in this district were not found in the Sierra Vieja district.

The birds of the Sierra Vieja region, including the Rio Grande district, represent three different faunal elements: the wide ranging forms which occur throughout much of North America, the species limited mainly to Mexico, and those birds which are wide-ranging in the western part of North America.

The faunal affinities of the birds of these districts are summarized as follows: 26 species (41.2%) widely distributed, 13 species (20.6%) Mexican, and 24 species (38.0%) wide ranging in western North America.

Fifty-five (46.6%) of the breeding birds listed from Brewster County by Van Tyne and Sutton (1937) were not recorded in the Sierra Vieja range. Forty-seven (54.6%) of the breeding birds of the Guadalupe Mountains as listed by Burleigh and Lowery (1940) were not found there. Of the species from Brewster County not recorded in the Sierra Vieja range, 14.2% occurred at higher altitudes than were present in the area covered by this survey. Likewise, 61.8% of the Guadalupe Mountain breeding birds which we failed to find occurred at high altitudes.

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TRENDS IN RELATIVE EMPHASIS UPON NATURAL AND SOCIAL SCIENCE

David G. Steinicke, Assistant Professor
Department of Agricultural Economics and Sociology
Agricultural and Mechanical College of Texas

INTRODUCTION

Many of us are aware of considerable difference in the emphasis that has been given to natural and social science. The recent war accented this difference. A number of writers have observed this thoughtfully and published their reactions. Included among them are George Lundberg, Stuart Chase, Warner Gettys, and Harry Barnes. I have borrowed liberally from them since their ideas fit my own thinking very well.

THE PRESENT SITUATION

Human ingenuity has produced some spectacular achievements in recent years. As a result humanity faces sharply drawn and dramatic alternatives. We have the means of achieving reasonably soon either a literal material utopia or else a reversion to barbarism and chaos. Progress in natural science has produced machines and devices with these opposite potentialities. If we are able to improve our human relationships, overtake our machines, and put these machines to work in the service of mankind we cannot very well avoid attaining a material utopia. This will provide us with ample leisure and security to build up more creditable and impressive forms of human achievement on the firm foundation of material prosperity. If, however, the machines and techniques produced by physical and natural science continue greatly to outdistance the institutions we use to carry on our human relationships, we face the prospect of economic depressions, the growth of totalitarianism, devastating world wars, and the destruction of civilization.

We have worked wonders by the application of technology to the problems of our physical environment, but we are scarcely conscious of the application of science in the realm of human relations. In fact, we hardly recognize the existence of inventiveness in the social sphere. Yet democratic government, capitalism, the Social Security Act, the United Nations, and UNESCO are inventions no less than the atom bomb, and they are just as capable of technical improvement.

As a people, Americans have come to appreciate the need for experimental research and technical training in the natural science field, but we still tend to think that good will, tolerance, and the cooperative spirit are all we need to make society function properly. These attitudes are vitally necessary; we shall make little progress without them; and education should concern itself with developing them. But alone they are not enough. Social techniques and social mechanisms must be found to express and implement them.

One often hears or reads, for example, puzzled questioning as to why man's intense desire for security and his fear of another war have produced so little actual progress toward peace in the world. But man's fear of smallpox did not eliminate that scourge until medical science and technology had invented and improved the technique of vaccination. Nor did man's desire to fly enable him to accomplish that feat until scientific ingenuity and engineering skill had produced the necessary mechanism and had trained men to use it.

In comparable fashion it will take a great expansion in social science research and social engineering to solve the problems of human relations. We must learn to respect the need for special knowledge and technical training in this field as we have come to defer to the expert in physics, chemistry, medicine, and other sciences.

TRENDS

During the past hundred years the material aspects of our culture have undergone revolutionary changes due to the tremendous development in natural science and technology. Man has become accustomed to the new tempo of living and has accepted scientific and technological progress, but has failed to adjust his social ideas and institutions to the new pattern of its material culture. Indeed, men are trying to manage a world of machines with ideas of the horse-and-buggy days and, in some cases, of the stone age. This failure to modernize our social ideas and institutions makes us wonder if we can control this technological age. Certainly since Hiroshima many are asking if the human sciences can really catch up with the atomic bomb.

Unless social science enables us to use our marvelous technology wisely and efficiently, the technology may well prove a liability rather than an asset, and be used as an instrument for the destruction of our civilization.

Social science acquired emphasis and funds for research during the twenties and thirties. Such agencies as the Rockefeller Foundation, the Laura Spellman Rockefeller Memorial, and the Russell Sage Foundation were generous in financing social science studies. The Social Science Research Council was formed and launched an ambitious program of stimulating, fostering, and financing research. Universities and state legislatures provided funds and other support for social science research.

As the depression of the thirties continued, the support for this research diminished, and by 1940 very little remained. Millions of dollars were provided for research and training in natural science during the war. At the same time research and training in social science reached a low ebb. We won the war with technical knowledge of physical forces; we have yet to win the peace with knowledge of social forces. We need much more research and training in social science to reach this goal. Perhaps social scientists may justly ask for a "Manhattan Project" in human relations to insure peace.

WHY HAS THIS BEEN SO?

Traditionally we have not regarded human relations as proper subjects for serious scientific study. Moreover, most people feel that by common sense we can get the answers to the problems of human relations. Solutions advocated include The Golden Rule, Free Enterprise, Cooperation, World Union, and the Ten Commandments.

Being rather materialistic we readily see the value of research in natural science, but scorn the less tangible products of social science. Furthermore, there are groups who profit, or think they profit, by the existence of social problems such as war, economic depressions, and the like. But the application of almost every advance in natural science has been similarly opposed by those who had vested interests in the ignorance and superstition of people. Only the demonstrable superiority of scientific knowledge defeated such interests.

Many people do not even know what social science means. Evidence of how poorly informed many people in high places are, about social science, was revealed in 1946 when the Senate was considering a bill to provide a National Science Foundation. This provided that the Federal Government was to subsidize science on a generous scale, especially through fellowships for talented students. Before the atom bomb, Congress would have had little interest in such a proposal, but now most Senators were in favor of it.

But should social science be included? The Senaors were not sure what social science meant. Here are some of the comments made during that discussion:

> Senator Fullbright: I asked an able scientist yesterday if he could define social science. He said: "In the first place I would not call it science. What is commonly called social science is one individual or group telling another group how they should live."
>
> Senator Hart: The fact is that social studies and basic science are not sufficiently alike either to be joined by the same legislation, or to be administered by the same organization. No agreement has been reached as to what social science really means. It may include philosophy, anthropology, all kinds of economics, literature, perhaps religion, and various kinds of ideology.
>
> Senator Smith: I should like to see social science given aid, but I think their problem is such a different one that the two should not be joined in this bill . . . We are trying to subsidize pure science, the discovery of truth. This has nothing to do with the theory of life, nothing to do with sociology.
>
> Dr. John M. Potter (late president of Hobart College): Some people think you can extend the strict scientific method into almost every region of human affairs. I don't happen to believe it. I was trained as a historian . . . These things it seems to me could

> be far better supplied by experienced men like Mr. Baruch, or by you gentlemen here in the Senate . . . Statistics . . . ought to be interpreted by the Congress of the United States . . . Congress should provide for a division of the humanities, rather than the social sciences. Such a division should not engage in research . . . it should stir concern among young men and women for the accumulated wisdom of our civilization.

After some discussion, the Senate passed the bill, but with social science left out. No subsidies were provided for the study of man and human relationships.

This Senate seminar in social science is an example of the confused thinking in this field. Even distinguished people are just beginning to become aware of the subject. The discussion revealed that everyone seems to feel that he knows the answers to the problems of human relations or that he can obtain the answers from radio commentators, politicians, preachers, or editorials in newspapers. What we and our leaders must realize is that useful knowledge of human relations, just as is true for natural science, may be obtained only by hard, painstaking research conducted by adequately trained social scientists.

Among those present at these Senate hearings was a great physicist who took part in releasing atomic energy. This man, Dr. J. R. Oppenheimer, had the following comment to make about social science:

> I am aware of the difficulties of establishing in these fields (the social sciences) rigorous criteria of competence and qualification. Nevertheless at a time when the whole world realizes that many of its most vital problems depend on an understanding of human behavior . . . and of the regularities which underlie the operations of our varied society, we should recognize the great benefits which may come from attracting men and women of prominence to the study of these questions.

Dr. Oppenheimer's reference to the regularities underlying human relationships is revealing of his confidence in our being able to discover what they are.

While no statistics are available on the relative emphasis in education upon natural and social science, it is generally agreed that natural science enjoys much greater emphasis. A survey of the college degrees granted during the year ended June 30, 1948, by the United States Office of Education showed that the degrees in natural science and technologies were more than double the number granted in social science. A more detailed study of the comparative hours spent in these two fields might reveal that the difference is even greater.

Undoubtedly a substantial part of this situation is due to the fact that social scientists have failed as yet to convince any substantial number of persons that they are engaged in the pursuit of knowledge which can be proved to be true regardless of the personal prefernces, hopes, and the likes of the scientist himself. But all sciences have gone through this stage.

WHAT HAS SOCIAL SCIENCE ACHIEVED?

Some feel that social science has proved no evidence of its value. It is true that the results are not reflected to any great extent in our management of social affairs. But men have been accumulating data about human behavior in a form which will eventually permit generalization never before possible. Important instruments have been invented for measuring opinion, status, social participation, etc.

One of the simplest illustrations of a social instrument is the election ballot.

Indeed, the invention and perfection of instruments for the more accurate and precise observing and recording of social phenomena must be regarded as among the most important developments of social science. It is easy to point out flaws in these instruments—such as how the polls missed predicting correctly the outcome of the recent election—but it was easy to point out the flaws in the early microscopes and telescopes. Without these beginnings and the patient centuries of undramatic labor, sciences like bacteriology could not have appeared at all.

Many social science achievements are not dramatic or spectacular, yet they are significant. I refer to the transition in our time to more humane treatment of children, the poor, the unfortunate, and the mentally sick as the result of more enlightened education, social work, and programs of treatment. This must in a large measure be attributed to the expanding sciences of psychology, sociology, and psychiatry. Of course, whenever a war or a depression occurs journalists and preachers point to the impotence of economists and political scientists either to predict or prevent these disasters. But it is a fact that the course of events following World War I, down to and including the present, was predicted with great accuracy by some of our social scientists. That nothing was done about it is not the special responsibility of social scientists.

Further evidence can be cited of how the scientific method has been used profitably in the social science field. Just as the scientific steps which led to the secret of atomic energy can be traced, so also we can indicate the steps leading to present population theory:

1500's Parishes in England, Germany, and Holland began keeping record of christenings, marriages, burials, and with these records, birth rates, marriage rates and death rates could be calculated.

1654 Pascall and Permat formulated the theory of probability as the result of their interest in gambling odds.

1693 The Royal Society published Halley's life tables, the basis of actuarial science.

1790 The first United States Census was taken, recognized as the best national count so far.

1798 Thomas Malthus, aged 32, published the essay attempting to prove that in the long run man tends to reproduce himself faster than he can increase his food supply.

1812 LePlace carried probability theory another long step forward.

1883 Galton, a cousin of Darwin, published INQUIRIES INTO HUMAN FACULTY which developed the principle of frequency distribution curves.

1899 Pearson published the GRAMMAR OF SCIENCE, which still dominates statistical theory.

1932 R. R. Kuczynski developed the "reproductive index" to predict population growth based on potential mothers.

1936 Dublin and Lotka published LENGTH OF LIFE.

1941 U. S. Census of 1910 came out according to prediction, with an error of less than two-hundredths of one percent.

May I pause to ask if any geologist or physician can diagnose the location of oil or of human diseases with such a small error?

These steps revealed many "irregularities." They provided support not only for population theory and research, but also for probability mathematics, which is now vital to the development of biology, physics, and natural science generally.

Other excellent examples of useful social science findings are provided by the Census Bureau, the Scripps Foundation, the Milbank Memorial Fund, and others engaged in similar or related work of a character that measures up very well to the standards of natural science.

WHAT CAN BE DONE?

Can Social Science ever hope to catch up with natural science, the increasingly rapid advance of which constantly creates new problems? Certainly this is possible if we devote ourselves to the business with something like the seriousness, the money, and the equipment and personnel that we have devoted to research in natural science.

It is not advocated that the study in natural science be reduced. It does seem imperative that we speed our pursuit of knowledge in social science. Certainly perfecting techniques for insuring the democratic principles of peace, security, and happiness will be far more challenging than was the perfection of techniques for releasing atomic energy—and more important.

Instruction in science of all kinds in our schools lags behind our needs. We have become preoccupied with teaching science as a particular subject matter rather than as a method of study. If we wish to remedy this situation we must establish and require courses from the grades through high school and college which are definitely calculated to acquaint everyone with the broader meaning and methods of science. We must extend the application of this method to the realm of human behavior.

Furthermore, we need to set up social research laboratories which will rank with Massachusetts and California Institutes of Technology, Mellon Institute, and the research laboratories of Bell Telephone, General Electric and General Motors, not to mention many others. When social science is supported as generously as natural science has been, it may then be expected to produce comparable results.

A very appropriate summary for our present situation was given by Raymond Fosdick:

> We are discovering the right things in the wrong order, which is another way of saying that we are learning how to control nature before we learn how to control ourselves.

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