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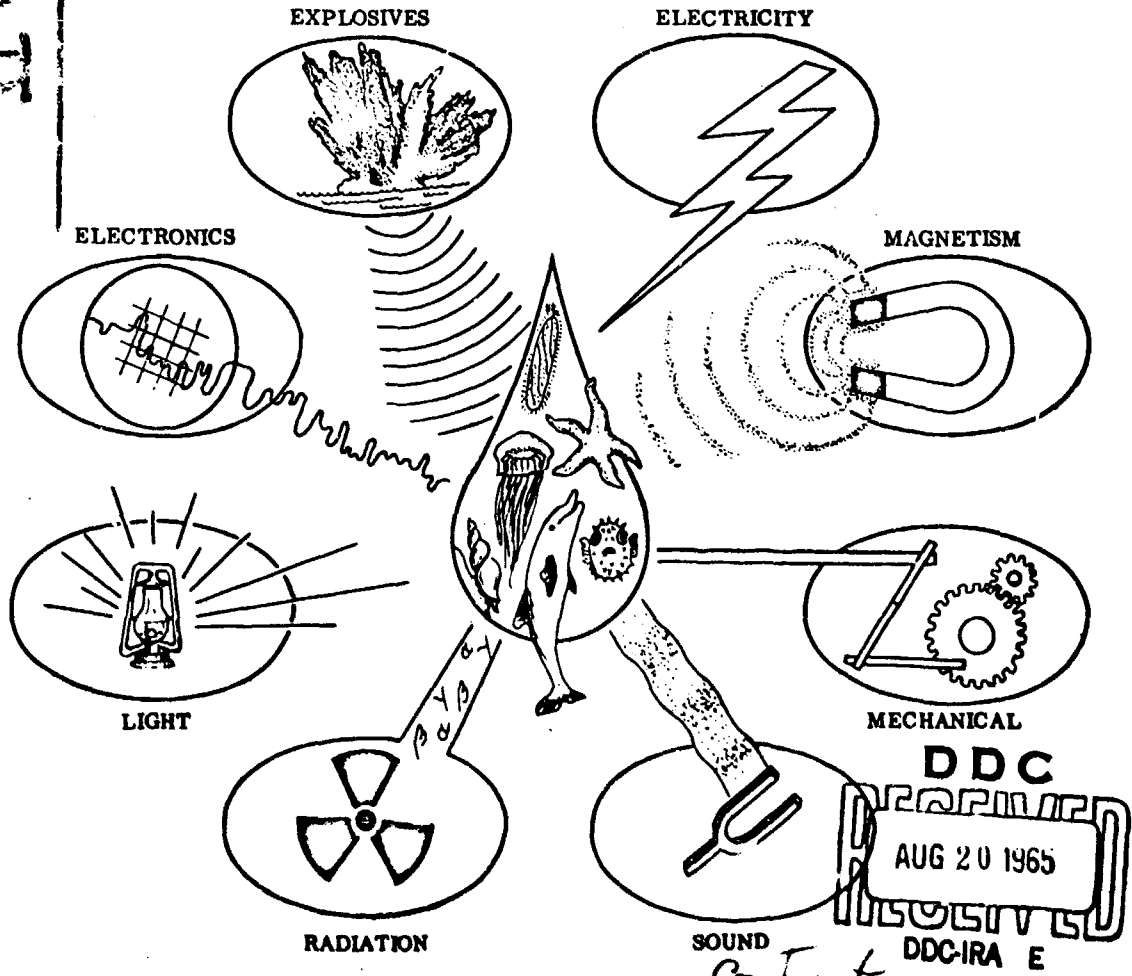
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# A BIBLIOGRAPHY Effects of External Forces on Aquatic Organisms

FRANK J. SCHWARTZ



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JANUARY 1961

CONTRIBUTION NO. 168

Chesapeake Biological Laboratory

SOLOMONS, MARYLAND

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⑥ Effects of External Forces on  
Aquatic Organisms. <

⑩ by FRANK J. SCHWARTZ,

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⑤ Chesapeake Biological Laboratory  
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**THE COVER:** The center represents a drop of water within which are shown a few of the wide range of animals covered by this bibliography: Paramecium, jellyfish, starfish, snail, burrfish and porpoise. The symbols in each of the ovals are those influences included in this bibliography: electricity (lightning bolt), magnetism and gravity (magnet), mechanics (gears and levers), sound (tuning fork), radiation (international radiation symbol), light (lantern), electronics (oscilloscope reading) and explosions (an underwater detonation) all of which are emitted or have some effects on the aquatic animals in the drop of water which may, in this case, be fresh or salt.

**HOW TO USE THE BIBLIOGRAPHY:** This bibliography lists 1216 references, grouped by subject matter: electricity, sound, etc. References marked with an asterisk (\*) contained material on more than one topic and will be found in the section noted after such references. A second section lists species alphabetically by the scientific, common or general names that were used in the original article. No attempt to correct published spelling errors or the systematic status of names was made. Thus one should check all possible ways that a species could be included (i. e.) Catfish, Ameiurus, Amiurus, Ictalurus, Silurus. The final section is an alphabetical listing of all the authors cited.

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## FOREWORD

Most biologists can readily think of references and organisms that have or can influence their environment. Fishes, such as the electric ray (Torpedo, Narcine), electric skate (Raia), electric eel (Electrophorus), American knife fish (Gymnotus), closely related Eigenmanni and Sternopygus, Mormyrids (Gnathonemus, Mormyrus), the Nile catfish (Malapterus) and the stargazer (Astroscopus) all can produce varying degrees of electrical impulses that stun, kill or attract other organisms to them as potential food. Many are familiar with the growing realization that the waters of the world are a noisy place. Porpoises, grunts, trigger fishes, catfishes, toadfishes, snappers, snapping shrimp and even seahorses are beeping, grunting, tooting, chattering or snapping a crescendo of noise at passing objects either as defense mechanisms, a courting ritual or as a means of food gathering. Familiar also are the glows that emit from jellyfishes (Liriope, Obelia, Cyanea, Aurelia) Ctenophora (Mnemiopsis), luminescent squid, Ectoproct Bryozoans, annelids, brittle starfish, lantern fishes (Myctophids), wide mouths (Stomiatooids), sharks, deep-sea anglers (Ceratioids) and rattail fishes (Macrurida). Whether this luminescence is used to dazzle, attract or confuse its enemy or prey, a soft white light from these sources glows from the surface of our waters down to a known depth of two and one-half miles (Galatheathuana axeli).

Few researchers consider the reverse aspect of the results of the effects of various external forces on aquatic organisms. What effects do electricity, explosions, light, magnetism, radiation and sound have on aquatic organisms whether in salt or fresh water? What species have been studied and how do they react to such stimulæ? These questions are the basis of this bibliography. Its scope is broad to encompass all groups of aquatic organisms so studied in the world's waters. In spite of the oddity to most biologists of such an approach a wealth of information was uncovered and is presented herein. I have, because of the broad nature of this bibliography, undoubtedly missed many references that exist on some group of animals or species. This is a beginning that can be made more complete in the future. Many "weighty" decisions had to be made: was it an effecting agent, was the species aquatic, etc. Such influences as chemicals, pollutants and temperature are obviously omitted as they are enormous bibliographic giants in themselves. I bear full responsibility for inclusion or exclusion of certain references in this list. Your additions and suggestions will be most welcome.

A task of this order could not have been performed without the generous efforts and support of many people. To mention a few, thanks are due: Dr. Sidney Galler, Head Biology Branch, and his aide Mrs. Helen Hayes, Office of Naval Research, for support of this project; Dr. L. Eugene Cronin, Director, Maryland Department of Research and Education, for making my time available to complete this study; Drs. Mary Sears and Bostwick Ketcham of Woods Hole Oceanographic Institute for bibliographic assistance; Mr. Halstead Wells, visiting student of the Antioch College Cooperative Student Program, Yellow Springs, Ohio, for assisting with the design and executing the cover drawing; the tireless work of Mrs. Gloria Lankford for having the monumental task of deciphering the hundreds of handwritten reference cards and patiently expediting the completion and final typing of the manuscript; and finally the many libraries and librarians, too numerous to mention, who searched diligently to uncover, obtain or make available the references cited in this bibliography. Without the efforts of all these people or agencies, this report would still be in its infancy. To all my heartiest thanks for their interest and aid.

Maryland Department of Research and Education

Frank J. Schwartz  
January 1, 1961



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## *Effects of External Forces on Aquatic Organisms*

### Electricity

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## Electronics

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- 499 \_\_\_\_\_. 1956. Electronic fish counter developed. Comm. Fish. Rev. 18(7):31-32.  
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## Explosives

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A wampus proved ineffective at disturbing fish. Successive small explosions didn't have a direct effect either.
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- 508 Cole, R. H. 1948. Underwater explosions. Princeton Univ. Press, Princeton, N. J. 436 pp.  
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- 509 Eklund, C. R. 1946. Effect of high explosive bombing on fish. Jour. Wildl. Mgt. 10(1):72.  
Bombs dropped from planes and exploded did not kill whitefish. These bombs were used to break holes in the ice of several lakes where 3 feet of ice had covered them.
- 510 Fitch, J. E. and P. H. Young. 1948. Use and effect of explosives in California coastal waters. Calif. Fish and Game 34(2):53-70.  
Charges up to 80 pounds were detonated in or on the sea floor. Kills of up to 21,000 pounds of fish were made. The number of fish on the bottom which didn't float was negligible. A true picture of the kill remains yet to be obtained.
- 511 Fry, D. H. and K. W. Cox. 1953. Observations on the effect of black powder explosions on fish life. Calif. Fish and Game 39(2):233-236.  
Shots of 45 pound strength were not effective on sea anemones and Sebastes.
- 512 Gowanloch, J. N. 1950. The effects of underwater seismographic exploration. Univ. Miami Mar. Lab. Proc. Gulf and Carib. Fish. Inst. 2nd Annual Session, pp. 105-106.  
Shrimp, crabs and fish were affected to a small degree.
- 513 \_\_\_\_\_ and J. E. McDougall. 1944. Louisiana experiments pave way for expanded oil research. La. Cons. 3(1):3, 6.  
It is feared the use of dynamite by oil exploratory groups will kill a lot of sea life.

- 514 \_\_\_\_\_ and \_\_\_\_\_. 1945. Effects from the detonation of explosives on certain marine life. *Oil* 4(12):13-16.  
Fish were not affected at 20, but were killed if within 150 yards.
- 515 \_\_\_\_\_ and \_\_\_\_\_. 1946. The biological effects on fish, shrimp and oysters of the underwater explosion of heavy charges of dynamite. *Tr. 11th N. Am. Wildl. Conf.* pp. 217-219.  
Kill varied by size of shot and distance animals were away from it.
- 516 Hubbs, C. L. and A. B. Rehnitzner. 1952. Report on experiments designed to determine effects of underwater explosions on fish life. *Calif. Fish and Game* 38(3):333-366.  
Black powder is less effective than dynamite in producing negative pressure to which fish are very susceptible. Dynamite peak pressures of 40-70 psi killed fish whereas 124-160 psi were necessary before kills with black powder occurred. Oil exploration can continue without undue destruction to the fauna.
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The use of plastic C-2 killed 99,000 gms of fish, but not in first 20 meters of the charge.
- 518 Kavanagh, L. D. 1939 (?). Explosions effects on oysters. *La. Cons. Dept. Rept.*
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- 520 Koyama, T. 1954. Effect of dynamite explosion on fish. *Tokai Reg. Fish. Res. Lab. Bull.* 8:23-29. (In Japanese with English summary).  
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- 522 (Margreiter)? 1932. Fischfang mit elektrischen strom. *Der Tiroler u. Vorarlberger Fischer Bd* 7:85.  
\* Nehru, J. 1958. See Radiation, Atomic.
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Forty feet away oysters were not affected by a blast. Those subjected to gases for up to 8 months were not affected. After 8 months those oysters 20-250 feet away showed no affect nor were different than so called normal oysters from other areas.
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Charges up to 1200 pounds had varying degrees of kill. No weight of fish to charge size position or depth correlation was found. Menhaden were the most readily killed fish. Heaviest mortalities were noticed in spring followed by winter, fall and summer.
- 525 Tyler, R. W. 1960. Use of dynamite to recover tagged salmon. *U. S. Fish & Wildl. Serv. Spec. Sci. Rept.* 353:1-9.  
Dynamite can be used to recover tagged salmon and is effective if the direction is controlled.

# Light

## A

- 526 Alfonsi, B. 1933. Confronto fra due tipi di lampada usate nella pesca luminosa nei regaiardi della penetrazione delle loro luci nell'acqua di mare. *Boll. Pesca, Piscicoltura e Idrobiol.* 9:1062-1067.  
The use of lights for fishing and their effective depth penetration are discussed.
- 527 Allison, L. N. 1951. Delay of spawning of eastern brook trout by means of artificially prolonged light intervals. *Prog. Fish Cult.* 13:111-116.
- 528 Andrews, C. W. 1946. Effect of heat on the light behavior of fish. (Proc.) *Tr. Roy. Soc. Can. Ser. 3*, 40:27-31.  
Temperature of susceptibility varied directly with the light intensity. This aspect decreased with age.
- 529 \_\_\_\_\_. 1952. Sensitivity of fish to light and the lateral line system. *Physiol. Zool.* 25(3):240-242.
- 530 Anon. 1949. Fiske med lys og elektrisitet. *Fiskets Gang (Bergen)*, 35(44):508.  
Lights were used by the Norwegians to raise the sild catch.
- 531 \_\_\_\_\_. 1949. Fixednet fishing with lamp lures. *Fish. Newsletter* 8(5):19.
- 532 \_\_\_\_\_. 1949. Trends and development. *Comm. Fish. Rev.* 11(2):48-49.  
An early paper pointing out the advantages of increased catches made possible by the use of electric lamps.
- 533 \_\_\_\_\_. 1950. Fixednet fishing with lamp lures. *España Pesquera* (2):7. (In Spanish).  
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- 534 \_\_\_\_\_. 1950. Night fishing for horse mackerel at Uchiura. *Comm. Fish. Rev.* 12(1):47.  
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- 535 \_\_\_\_\_. 1952. Marine fouling and its prevention. U. S. Naval Inst., Annapolis, Md., 388 pp.  
It was believed lights and electrical stimulus would keep organisms off ships hulls to no avail.
- 536 \_\_\_\_\_. 1952. The lure of light. *Pacific Fisherman* 50(8):26-27.  
Sardines are easily lured to the surface for capture by lights.
- 537 \_\_\_\_\_. 1952. A pesca com luz eléctrica (Fishing with electric light). *Boletim de Pesca (Portugal)* 9(37):110. (In Portuguese).  
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- 538 \_\_\_\_\_. 1952. La pesca con luz eléctrica (Fishing with electric light). *España Pesquera* 33:31. (In Spanish).  
Similar to 533.
- 539 \_\_\_\_\_. 1958. Attraction of fish by lights only effective with certain species. *Western Fish.* 57:28-34.  
Herring, cod and hake fishes are more easily attracted to the surface by a light than most marine fishes.
- 540 \_\_\_\_\_. 1958. Japanese find blue and green lights catch most shellfish. *The Fishing News (London)* 2365:13, 15.  
Blue and green lights seemed to increase the lobster and crab catches greatly.
- 541 \_\_\_\_\_. 1959. Modern fishing gear of the world. *Fishing News Ltd., London*, 1500 pp.  
A number of papers which deal with types of lights, intensities and use of lights to catch fish and shellfish are included.
- 542 \_\_\_\_\_. 1960. Colored lights for attracting fish and new method of setting sampling nets tested. *Comm. Fish. Rev.* 22(9):15.  
Blue, red and white lights above and below the surface were tested. Blue had no effect whereas red did with lower catches ensuing.
- 543 \_\_\_\_\_. Pit lamping pays off. *Pacific Fisherman* 58(1):31-32.  
Herring were easily collected with lights.

## B

- 544 Bainbridge, R. and T. H. Waterman. 1957. Polarized light and the orientation of two marine crustacea. *Jour. Exp. Biol.* 34(3):342-364.  
Palaeomon and Mysidium orientate toward a light or its axis.
- 545 \_\_\_\_\_. and \_\_\_\_\_. 1958. Turbidity and the polarized light orientation of the crustacean Mysidium. *Jour. Exp. Biol.* 35(3):487-493.  
Mysidium swims perpendicular to plane of polarization when water is turbid.
- 546 Baldwin, W. M. 1919. The artificial production of monsters conforming to a definite type by means of x-rays. *Anat. Rec.* 17:175-183.  
The effects of x-ray treatment are delayed in their appearance.
- 547 Balls, R. 1951. Environmental changes in herring behavior: a theory of light avoidance as suggested by echosounding observations in the North Sea. *Jour. du Cons.* 17:274-290.

- 548 Bateson, W. 1889. The sense-organs and perception of fishes. Modes in which fish are affected by artificial light. Jour. Mar. Biol. Assoc., U.K., (n.s.) 1:46.
- 549 Bauer, V. 1910. Über das farbenunterscheidungsvermögen der fische. Pflügers Archiv. f. d. ges. Physiol. des Menschen und der Tiere, Berlin-Göttingen-Heidelberg, 133:7-26.  
Various species of marine fishes from Box to Cobitis are attracted to a light source.
- 550 \_\_\_\_\_ . 1911. Zu meinen versuchen über das farbenunterscheidungsvermögen der fische. Pflügers Archiv. f. d. ges. Physiol. 137:622-626.  
A discussion of the affects of red and blue light on fish. Red usually produces a negative reaction or behavior.
- 551 Baylor, E. R. 1959. The responses of snails to polarized light. Jour. Exp. Biol. 36(2): 369-376.  
Nassa obsoleta orientates at right angles to vertically positioned polarized light.
- 552 \_\_\_\_\_ and F. E. Smith. 1953. The orientation of Cladocera to polarized light. Am. Nat. 87:97-101.  
Cladocera are readily attracted to a light source and swam at right angles to the light source.
- 553 Beebe, W. 1935. Resume of the 1935 expedition of the Department of Tropical Research. N.Y. Zool. Soc. Bull. 38(6):191-196.  
Various organisms would remain in the area as long as an ultra violet light was on.
- 554 Behre, Ellinor H. 1933. Color recognition and color changes in certain species of fishes. Copeia (2):49-58.  
Daylight (and 6 types of colors) produced a darkening while absence of light produced the reverse. Fading occurred in the following order of type of light: blue, red, minus green, minus red and green. Red end is responsible for darkening and short wave lengths counteract this.
- 555 Bert, P. P. 1868. Les animaux voient ils les mêmes rayons lumineux que vous. Mem. Soc. Sc. Phys. et Nat. Bordeaux, pp. vi / 375-483.
- 556 Beuther, E. (1927). Ueber die einwirkung verschiedenfarbigen lichtetes auf Planarien. Sitzungsber u. Abhandl. Naturforsch. Ges. Rostock Ser. 3, 1:17-57.
- 557 Blaxter, J. H. S. and B. B. Parrish. 1958. The effect of artificial lights on fish and other marine organisms at sea. Scottish Home Dept. Mar. Res. (2):24 pp.
- 558 Blinov, A. F. 1958. Nekotorye dannye o reaktivnosti sel'di na elektrosvet (Certain data on reactions of herring to electric illumination). Rybnoe Khoziaistvo 34(2):33-34. (In Russian).  
A lamp is ineffective for this species; a search light is better.
- 559 Borissov, P. G. 1955. The behaviour of fishes under the influence of artificial light. Proc. Conf. on behavior of fish and on locating its commercial concentrations. Ed. by E. N. Pavlovskii, Moscow, pp. 121-143. (In Russian).
- 560 \_\_\_\_\_ . 1956. Use of artificial light in the world fisheries. Moscow, 10 pp. (In Russian).
- \* Brawn, Vivien M. 1960. See Mechanical.
- 561 Breder, C. M., Jr. 1934. An experimental study of the reproductive habits and life history of the cichlid fish, Aequidens latifrons (Steindachner). Zoologica 18(1):1-42.
- 562 \_\_\_\_\_ . 1944. Ocular anatomy and light sensitivity studies on the blind fish from Cueva de los Sabinos, Mexico. Zoologica 131-143; 674-675, 677.  
Astyanx is indifferent to light.
- 563 \_\_\_\_\_ . 1951. Studies on the structure of the fish school. Am. Mus. Nat. Hist. Bull. 98(1):1-28, 9 figs., 4 pls., 3 tables.  
A classical paper and excellent report on the schooling of this species in a light zone. Patterns break up if light is extinguished.
- 564 \_\_\_\_\_ . 1959. Studies on social groupings in fishes. Am. Mus. Nat. Hist. Bull. 117 (Art. 6):399-481, pls. 70-80.  
A good paper on the orientation of many species of marine fishes which are dependent on light in order to form a school.
- 565 \_\_\_\_\_ and E. B. Gresser. 1941. Correlations between structural eye defects and behavior in the Mexican blind characin. Zoologica 26(16):123-131.  
Astyanax is a sensitive form which is killed if the light intensity was too great.
- 566 \_\_\_\_\_ and P. Rasquin. 1947. Comparative studies in the light sensitivity of blind characins from a series of Mexican caves. Am. Mus. Nat. Hist. Bull. 89:319-352.  
A very good paper dealing with the light and dark reactions of blind characins.
- 567 \_\_\_\_\_ and \_\_\_\_\_ . 1950. A preliminary report on the role of the pineal organ in the control of pigment cells and light reactions in recent Teleost fishes. Sci. 111(2871):10-12.  
Five species were positively attracted to light, 4 were neutral and 10 were negative in their pigments reactions to light.

- 568 Brett, J. R. and D. MacKinnon. 1953. Preliminary experiments using lights and grabbles to deflect migrating young spring salmon. *Jour. Fish Res. Bd. Can.* 10(8):548-559.
- 569 Brown, F. A. 1936. Light intensity and melanophore response in the minnow Ericymba buccata Cope. *Biol. Bull.* 70:8-15.  
A good paper. Above .00053' candles fish are at maximum degree of paleness, in spite of background.
- 570 Brown, F. A., Jr. 1937. Responses of the largemouth black bass to colors. *Ill. Nat. Hist. Surv. Bull.* 21(2):33-55.  
Largemouth bass trained to four colors responded best to red.
- 571 Bull, H. O. 1928. Studies on conditioned responses in fishes Pt. I. *Jour. Mar. Biol. Assoc., U.K., N.S.* 15(2):485-533.  
Electrical, color and sound conditioning was established for Blennius, Crenilabrus and Labrus. Crenilabrus could distinguish between red and green.
- 572 \_\_\_\_\_ . 1930. Studies on conditioned responses in fishes Pt. II. *Jour. Mar. Biol. Assoc., U.K., (N.S.)* 17:615-637.  
See 571.
- 573 \_\_\_\_\_ . 1935. Studies on conditioned responses in fishes. Pt. III. Wavelength discrimination in Blennius pholis L. *Jour. Mar. Biol. Assoc., U.K., N.S.* 20:347-364.  
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- 574 Bullough, W. S. 1941. The effect of the reduction of light in spring on the breeding season of the minnow (Phoxinus laevis). *Proc. Zool. Soc. London, Ser. A*, 110:147-157.
- 574a Burdon-Jones, C. and G. H. Charles. 1958. Light reactions of littoral gastropods. *Nature* 81:129-131.
- 575 Burger, J. W. 1937. Experimental sexual photoperiodicity in male turtle, Pseudemys elegans (Wied). *Am. Nat.* 71(736):481-487.
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The endocrine system of Astyanax is not affected by different wave lengths of light.
- 577 Caneila, M. F. 1937. Azione degli stimoli luminosi sulla posizione d'equilibrio dei pesci. *Boll. della Societa Italiana di Biologia Sperimentale* 12:2 pp.
- 578 Catala-Stucki, R. 1959. Fluorescence effects from corals irradiated with ultra-violet rays. *Nature* 183(4666):949.  
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- 579 Chellappa, D. E. 1959. A note on the night fishing observations from a Kelong. *Jour. Mar. Biol. Assoc., India*, 1(1):53-54.
- 580 Clark, F. N. 1956. Average lunar month catch of sardine fishermen in southern California 1932-33 through 1954-55. *Calif. Fish and Game* 42(4):309-323.  
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- 581 \_\_\_\_\_ and Anita E. Daugherty. 1950. Average lunar month catch by California sardine fishermen 1932-33 through 1948-49. *Calif. Fish and Game Fish Bull.* 76:28 pp.  
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- 582 \_\_\_\_\_ and \_\_\_\_\_. 1952. Average lunar month catch by California sardine fishermen 1949-50 through 1950-51. *Calif. Fish and Game* 38(1):85-97.  
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- 583 Cobb, J. N. 1903. The commercial fisheries of the Hawaiian Islands. *U.S. Fish Comm. Bull.* 23:717-765.  
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- 584 Combs, B. D., R. E. Burrows and R. G. Bigl. 1959. The effect of controlled light on the maturation of adult blueback salmon. *Prog. Fish Cult.* 21(1):63-69.
- 585 Commercial Fisheries Review. 1960. Tunisia: Fishery trends, second quarter 1960. *Comm. Fish. Rev.* 22(11):86.  
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- 586 Corson, B. W. 1955. Four years' progress in the use of artificially controlled light to induce early spawning in brook trout. *Prog. Fish Cult.* 17(3):99-103.  
Trout, 2-1/2 years old, produce better eggs which hatch out better when under artificial light than if older.
- 587 Craig, R. E. and I. G. Baxter. 1952. Observations in the sea on the reaction to ultra-violet light of certain sound scatterers. *Jour. Mar. Biol. Assoc., U.K.*, 31(2):223-227.
- 588 Crawford, D. R. 1930. Some considerations in the study of the effects of heat and light on fishes. *Copeia* (173):89-93.  
Yellow and green were good but blue caused high mortalities among young salmon.

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T

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Y

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- \* Lynch, W. F. 1947. See Light.

## Mechanical

### A

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### B

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I

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L

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M

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P

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R

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W

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## Radiation: Atomic

A

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- 1057a \_\_\_\_\_ and V. I. Zhadin. 1957. Radiomarkirovka rybtsa i shemai kak metod ustanovleniia effektivnosti raboty Rybtsovo-Sheimainogo petomnika. (Radiomarking of vimba and bleak for disclosing the operational efficiency of the vimba bleak nursery). Trud. Probl. Temot. Soveshrch. Zool. Inst. Akad. Nauk SSSR 7:57-61.
- V
- 1058 Vinogradov, A. P. 1953. The elementary chemical composition of marine organisms. Sears Found. Mar. Res. Mem. (11):536.  
Radium is found in the same order in fish as in invertebrates, higher than in sea water, but lower than marine algae.
- W
- 1059 Watson, D. G. and J. J. Davis. 1957. Concentrations of radioisotopes in Columbia River whitefish in the vicinity of the Hanford Atomic Products operations. A. E. C. Rept. (HW-48523(Dd)):133 pp.  
A 1950-56 study. Maximum radioactivity in whitefish was near Hanford Atomic Reservoir.
- 1060 Weiss, H. V., S. H. Cohn, W. H. Shipman and J. K. Gong. 1956. Residual contamination of plants, animals, soils and water of the Marshall Islands two years following operation castle fallout. Res. and Develop. Rept., U.S. Naval Radiobiol. Def. Lab., San Francisco 24, Calif., Doc. 455NS081-001:52 pp.  
Radioactivity decreased by 80% in one year. Fish had only 25% of radioactivity one year later. The skeleton of fish was not high in radioactive materials.
- 1061 \_\_\_\_\_ and W. H. Shipman. 1957. Biological concentration by killer clams of Cobalt $^{60}$  from radioactive fallout. Science 125(3250):695.
- 1062 Welander, A. D. 1957. Radioactivity in the reef fishes of Belle Island, Eniwetok Atoll April 1954 to Nov. 1955. A. E. C. Rept. UWFL-49):42 pp.  
A study of the levels of contamination in fishes right after a bomb blast.
- 1063 \_\_\_\_\_. 1957. Radiobiological studies of the fish collected at Rongelap and Ailinginae Atolls, July 1957. U. S. A. E. C. UWFL Appl. Fish. Lab. 55:1-30.  
Most radiation was in muscle, bone, liver and stomach content: Zn $^{65}$  and Mn $^{54}$  in bone; Zn $^{65}$ , Co $^{57}$ , Co $^{60}$  and Mn $^{54}$  in soft tissues.
- 1064 Wichterman, R. 1957. Biological effects of radiations on protozoa. Bios 28:3-20.
- 1065 Wiercinski, F. J. and J. K. Taylor. 1960. Experiments with Ca $^{45}$  in marine egg cells. Abstr. Biol. Bull. 119(2):299.  
Little uptake by *Arbacia* and *Spissula* in Ca $^{45}$  solution. If exposed to ultraviolet light for long periods of time the uptake of Ca $^{45}$  increased.
- 1066 Williams, L. G. 1960. Uptake of Cesium $^{137}$  by cells and detritus of *Euglena* and *Chlorella*. Limnol. and Oceanog. 5(3):301-311.
- 1067 \_\_\_\_\_ and Q. Pickering. 1961. Direct and food-chain uptake of Cesium $^{137}$  and strontium $^{85}$  in bluegill fingerlings. Ecology 42(1):205-206.  
Higher content of Ce and Sr was obtained in bluegills by the *Euglena-Daphnia* food chain method than absorption from the water. The counts were exponential for the first 4 days and by 20 days had dropped to only 8% of the initial reading. K or Ca in the water affected the amount and rate of Ce uptake.
- 1068 \_\_\_\_\_ and H. D. Swanson. 1958. Concentration of Cesium $^{137}$  by algae. Science 127(3291):187-188.  
Dead *Chlorella* and *Euglena* react differently than when alive in its uptake of Ce $^{137}$ .

- 1069 Wooster, W. S. and B. H. Ketchum. 1957. Transport and dispersal of radioactive elements in the sea. The Effects of Atomic Radiation on Oceanography and Fisheries. Nat. Acad. Sci. Nat. Res. Council Publ. 551:43-51.  
A discussion of diffusion rates of radioactive material and then possible uptake by aquatic organisms.

Y

- 1070 Yamada, K., H. Tozawa, K. Amano and A. Takase. 1955. Radioactivity in the pelagic fish. II. Group separation of radioactive elements in fish tissues. Bull. Jap. Soc. Sci. Fish 20(10):916-920. (In Japanese).

- 1071 \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_. 1955. Studies on the radioactivity in certain pelagic fish. III. Separation and confirmation of Zn<sup>65</sup> in the muscle tissue of a skipjack. Bull. Jap. Soc. Sci. Fish 20(10):921-926.

A paper discussing tests for radioactivity extraction method determinations.

- 1072 Yoshii, G. 1956. Studies on the radioactive samples (especially "*Katsuwonus vagans*") in the Pacific Ocean in 1954. Vol. II Res. in Effects and Influences of the Nuclear Bomb Test Exp. Ueno, Tokyo, Jap. Soc. Prom. Sci., pp. 917-936.

Z

- 1073 Zirkle, R. E. 1936. Biological effects of Alpha particles. In: Biol. Effects of Radiation. McGraw Hill, N.Y., 1st Ed. pp. 559-572.

A review.

## Radiation: X-ray

A

- 1074 Allen, B. M. 1958. Effects of x-irradiation upon the limb-buds of *Bufo boreas*. Anat. Rec. 130:391.
- 1075 \_\_\_\_\_ and L. M. Ewell. 1960. Resistance to x-irradiation by embryonic cells of the limb-buds of tadpoles. Jour. Exp. Zool. 142:309-329.  
In tadpoles receiving 1000-30000 R the younger cells were more sensitive than older cells.
- 1076 Anon. 1955. Section 10 on series of experiments involving the effect of x-ray on fishes: fingerling chinook salmon (*Oncorhynchus tshawytscha* Walbaum). A. E. C. Rept. (UWFL-3):71 pp.  
In 4 weeks 2500 and 5000 roentgens caused 100% death. The 1250 R group after 12 weeks had only 70% of the weight the controls did.

B

- 1077 Baldwin, W. M. 1915. The action of ultraviolet rays upon the frog's egg. Anat. Rec. 9:385-391.  
Ultraviolet rays affects the eggs of frogs and all body parts disastrously.
- \* Baldwin, W. M. 1919. See Light.

- 1078 Bordeen, C. R. 1907. Abnormal development of toad ova fertilized by spermatozoa exposed to the Roentgen rays. Jour. Exp. Zool. 4(1): 1-44 / 5 pls.

Beyond the gastula stage, toad egg development was retarded.

- 1079 \_\_\_\_\_ 1909. Variations in susceptibility of Amphibian ova to x-rays at different stages of development. Anat. Rec. 3(4):163-165.

- 1080 \_\_\_\_\_ 1911. Further studies on the variation in susceptibility of Amphibian ova to the x-rays at different stages of development. Am. Jour. Anat. 11:419-498.

The exposure and amount of x-ray dose is important to amphibian eggs for later development. The after effects of exposure do not appear for some time.

- 1081 \_\_\_\_\_ and F. H. Baetjer. 1904. The inhibitive action of the Roentgen rays on regeneration in Planarians. Jour. Exp. Zool. 1(1):191-195.

Radiation of *Planaris* inhibits all development or regeneration. The full after effects do not appear for several days.

- 1082 Barrington, E. J. W. and L. L. Franchi. 1956. Some cytological characteristics of thyroidal function in the endostyle of the ammocoete larva. Quart. Jour. Micr. Sci. 97:393-409.

- 1083 Bell, G. M. and W. S. Hoar. 1950. Some effects of ultra-violet radiation on sockeye salmon eggs and alevins. *Can. Jour. Res.* 28(10):35-43.  
Sockeye salmon eggs if irradiated will yield deformed specimens as well as the epidermal cells are usually destroyed.
- 1084 Belyayeva, V. N. and G. L. Pokrovskaya. 1958. Mitotic disturbance observed at early development stages in *Misgurnus fossilis* subjected to x-ray treatment. *Doklady Akad. Nauk SSSR* 125:632-635. (In Russian).  
The cleavage stage is most susceptible to irradiation in *Misgurnus* with 100% death usually the result.
- 1085 Bohn, G. 1903. Influence des rayons du radium sur les animaux en voie de Croissance. *Compt. Rend. Acad. Sci. (Paris)* 136:1012-1013.  
X-radiation of eggs of *Bufo vulgaris* produced monsters.
- 1086 \_\_\_\_\_, 1903. Influence des rayons du radium sur les oeufs vierges et fécondés et sur les premiers stades de développement. *Compt. Rend. Acad. Sci. (Paris)* 136:1085-1086.  
A poor paper which discusses the development of *Strongylocentrotus* eggs after irradiation.
- 1087 Bonham, K. 1949. Effects of x-rays on the fresh-water snail *Radix japonica*. A. E. C. Rept. (UWFL-21):30 pp., mimeo.
- 1088 \_\_\_\_\_, 1955. Sensitivity to x-rays of the early cleavage stages of the snail *Heliosoma subcrenatum*. *Growth* 19:9-18.  
Hard and soft rays effect didn't differ to this snail. However, the resting stage of developing eggs withstood greater roentgen doses than the mitotic stages, 300-400 R for resting and 100 R for mitotic before serious affects occurred.
- 1089 \_\_\_\_\_, 1955. Lethal effects of x-rays on marine amphipods. A. E. C. Rept. (UWFL-14):18 pp.  
Doses of 500 R and 1250 R increased the number of young which had higher mortalities.
- 1090 \_\_\_\_\_, R. R. Donaldson, H. F. Foster, A. D. Welander and A. H. Seymour. 1948. The effect of x-ray on mortality, weight, length and counts of erythrocytes and hematopoietic cells in fingerling chinook salmon, *Oncorhynchus tshawytscha* Walbaum. *Growth* 12:107-121.  
A good study of the effects of x-rays between 100-500 R. The lowest dose to yield mortality was 250 R, 500 R to affect weight and 100 R to affect length.
- 1091 \_\_\_\_\_ and R. F. Palumbo. 1951. Effects of x-rays on snails, crustacea and algae. *Growth* 15:155-188.  
A good study of *Radix*, *Thais*, *Artemia* and amphipod reactions to x-ray doses. All *Radix* died in a week if exposed to 20 R, *Artemia* eggs, if dry, 93 R, soaked 50 R, in 5 days while most amphipods withstood 550 R.
- 1092 \_\_\_\_\_ and A. H. Seymour. 1947. Sections I and II on series of experiments involving the effect of x-ray on fishes: chinook salmon (*Oncorhynchus tshawytscha* Walbaum) observed through more than one generation. A. E. C. Rept. (UWFL-6).  
Chinook salmon were most susceptible to x-rays while in the fry stage.
- 1093 \_\_\_\_\_, \_\_\_\_\_, L. R. Donaldson and A. Welander. 1947. Lethal effects of x-rays on marine microplankton organisms. *Science* 106(2750):245-246.  
Mastigophorans would die if exposed to x-ray doses above 25000 R.
- 1094 Borstel, R. C. 1955. Feulgen-negative nuclear division in *Habrobracon* eggs after lethal exposure to x-rays or nitrogen mustard. *Nature* 175:342-343.  
*Habrobracon* eggs were most susceptible to 10 KV during the metaphase. The Feulgen-negative nucleus appeared in 10 hours at this exposure.
- 1095 Briggs, R., E. U. Cuene and T. Y. King. 1951. An investigation of the capacity for cleavage and differentiation in *Rana pipiens* eggs lacking "functional" chromosomes. *Jour. Exp. Zool.* 116:455-499.  
*R. pipiens* eggs fertilized with sperm of *R. catesbiana* or *R. pipiens* which were subjected to 65-300 R yielded gynogenetic haploids.
- 1096 Brunst, V. V. 1950. Influence of x-rays on limb regeneration in Urodele amphibians. *Quart. Rev. Biol.* 25:1-29.
- 1097 Burkner, E., M. Shapiro and K. Bronstein. 1929. Radiumgehalt einiger nahrungsmittel. *Biochem. Zeitschr.* 211:323-325.  
A general paper dealing with the effects to *Cottus gobio*.
- 1098 Butler, E. G. 1933. The effects of x-radiation on the regeneration of the fore limb of *Amblystoma* larvae. *Jour. Exp. Zool.* 65:271-315.
- 1099 \_\_\_\_\_, 1936. The effects of radium and x-rays on embryonic development. In: *Biol. Effects of Radiation*, McGraw Hill Co., N. Y. 1st Ed. pp. 389-410.  
A good review of the subject from the aspect of x-ray effects to development. Best review of the literature to 1936.



1100 \_\_\_\_\_ and J. P. O'Brien. 1943. Effect of localized x-radiation on the Urodele limb. *Anat. Rec.* 84:407-413.

C

1101 Chase, A. M. and A. C. Giese. 1940. Effects of ultraviolet radiation on Cypridina luciferin and luciferase. *Jour. Cell. and Comp. Physiol.* 16:323-340.

A good study where short waves of radiation were found not to affect the extract.

1102 Colwell, H. A. and M. S. Thomson. 1926. On some effects of primary and secondary x-rays on the skin of the frog tadpole. *Lancet* 211(5367):59-61.

Those cells of R. temporaria which were directly in the x-ray beam were completely destroyed.

1103 Corbella, E. 1930. Influsso delle radiozioni roentgen sullo sulluppio embrionale du teleostei (Salmo lacustris L., Salmo iridis Gibb, Perca fluviatilis L.). *Riv. Biol. Milano* 12:93-117.

A good bibliography follows this study.

1104 Curtis, W. C. 1936. Effects of x-rays and radium upon regeneration. In: *Biol. Effects of Radiation*. McGraw Hill Co., N. Y. 1st Ed. pp. 411-457.

A good review of the x-ray effects to Porifera through amphibia.

D

1105 Daniels, E. W. 1955. X-irradiation of the giant amoeba Pelomyxa illinoisensis. I. Survival and cell division following exposure. Therapeutic effects of whole protoplasm. *Jour. Exp. Zool.* 130:183-197.

1106 \_\_\_\_\_. 1958. X-irradiation of the giant amoeba, Pelomyxa illinoisensis. II. Further studies on recovery following supralethal exposure. *Jour. Exp. Zool.* 137:425-442.

Continuation of 1105.

1107 Davison, C. and F. Ellinger. 1942. Radiation effects on nervous system and roentgen-pigmentation of goldfish (Carassius auratus). *Proc. Soc. Exp. Biol. and Med.* 49(3):491-495.

The medulla oblongata and anterior horns of the spinal chord were the structures most affected by x-rays.

1108 Donaldson, L. R. 1955. A radiological study of Rongelap Atoll, Marshall Islands, during 1954-55. *Univ. Wash. Appl. Fish. Lab. Rept.* UWFL-42:46 pp.

E

1109 Ellinger, F. 1939. Note on the action of x-rays on goldfish (Carassius auratus). *Proc. Soc. Exp. Biol. and Med.* 41(2):527-529.

Latent affects of x-rays didn't appear for 12 days.

1110 \_\_\_\_\_. 1940. The goldfish as a biologic test object in experimental radiation therapy. *Radiology* 35(5):563-574.

1111 \_\_\_\_\_. 1940. Roentgen-pigmentation in the goldfish. *Proc. Soc. Exp. Biol. and Med.* 45(1):148-150.

1112 \_\_\_\_\_ and C. Davison. 1942. Changes in the central nervous system of goldfish irradiated in the depths of a water phantom. *Radiology* 39(1):92-95.

F

1113 Foster, R. F. 1949. Some effects on embryo and young rainbow trout (Salmo gairdnerii Richardson) from exposing the parent fish to x-rays. *Growth* 13:119-142.

1114 \_\_\_\_\_, L. R. Donaldson, A. D. Welander, K. Bonham and A. H. Seymour. 1949. The effect on embryos and young of rainbow trout from exposing the parent fish to x-rays. *Growth* 13:119-142.

A good study. The more parents were radiated the more mortalities one had. At 1500 R 100% mortalities occurred. The first year growth of young was also affected.

G

1115 Gilman, P. K. and F. H. Baetjer. 1904. Some effects of the roentgen rays on the development of embryos. *Am. Jour. Physiol.* 10:226-234.

Accidental growth occurred for the first 36 hours after exposure. Most specimens were deformed. The eyes were usually retarded.

1116 Goodrich, H. B. and Priscilla L. Anderson. 1939. Variations of color patterns in hybrids of the goldfish, Carassius auratus. *Biol. Bull.* 77(2):184-191.

1117 \_\_\_\_\_ and J. P. Trinkaus. 1939. The differential effect of radiations on Mendelian phenotypes of the goldfish, Carassius auratus. *Biol. Bull.* 77(2):192-199.

H

- 1118 Hinrichs, M. A. 1955. Modification of development on the basis of differential susceptibility to radiation. I. Fundulus heteroclitus and ultra-violet radiation. Jour. Morph. 41:239-265.

K

- 1119 Kessler, R. and W. Luther. 1957. Die Wirkung der Röntgenstrahlen auf den Hoden und die sekundären Geschlechtsmerkmale von Lebistes reticulatus Peters. Zeitschr. Verg. Physiol. 40(5):492-528.

A good bibliography ends this paper. Larvae and juveniles were exposed to 500, 1000, 2000, 3000, 4000 R; 1000 R proved most lethal. The histology is also presented.

L

- 1120 Litschko (Licko), E. J. 1932. Further observations on the effect of x-rays on regeneration in Axolotl. Compt. Rend. Acad. Sci. URSS Ser. A, 3:65-70, 1 pl. (In Russian).

M

- 1121 McGregor, J. H. 1908. Abnormal development of frog embryos as a result of treatment of ova and sperm with roentgen rays. Science 27:445.

Only 5% of the R. sylvatica embryos exposed to x-rays were abnormal.

- 1122 Meserve, F. G. and M. J. Kenney. 1934. The effects of x-rays on Planaria doratcephala. Science 79:408-409.

X-rays affect the cell growth in Planaria.

- 1123 Murachi, K. 1944. The influence of radiation upon fish eggs. (1) The influence of KCL upon the heart of an embryo which has been kept under radiation of x-rays. Zool. Mag. (Dobutsugaku Zasshi) 56(8):5-7. (In Japanese).

N

- 1124 Neyfakh, A. A. 1959. X-ray inactivation of nuclei as a method for studying their function in the early development of fishes. Jour. Embryol. and Exp. Morphol. 7(2):173-192.

If anytime between fertilization and early gastrula stages the specimen is x-rayed, growth and development are arrested.

- Noddach, Ida and W. Noddach. 1939. See Electricity.

O

- 1125 Okada, I., I. O. Sakabe, T. Kikuchi and K. Konno. 1954. On the influence of x-ray radiation on the aquatic animals. On the influence in the early development of goldfish (Carassius auratus L.). Vol. II Res. in Effects and Influences of the Nuclear Bomb Test Exp. Ueno, Tokyo, Jap. Soc. Prom. Sci. pp. 1211-1218.

If one increases the x-ray strength, there is a decrease in the hatching rate.

P

- 1126 Packard, C. 1914. The effect of radium radiations on the fertilization of Nereis. Jour. Exp. Zool. 16:85-129.

X-rays stimulate Nereis to spawn. An egg nucleus develops without an aster.

- 1127 \_\_\_\_\_ . 1918. The effect of radium radiations on the development of Chaetopterus. Biol. Bull. 35:50-70.

- 1128 \_\_\_\_\_ . 1931. The biological effects of short radiations. Quart. Rev. Biol. 6:253-280.

A good review.

- 1129 Powers, E. L. and D. Shefner. 1950. Effects of high dosages of x-rays in Paramecium aurelia. Genetics 35:131.

If one uses 1,000,000 R at 62,000 per minute, 50% mortality occurs at 62,000 R. After this strength the mortality rate decreases.

- 1130 Puckett, W. O. 1936. The effects of x-radiation on limb development and regeneration in Amblystoma. Jour. Morph. 59:173-213.

R

- 1131 Rugh, C. 1955. Effects of various levels of x-irradiation on the gametes and early embryos of Fundulus heteroclitus. Biol. Bull. 108(3):318-325.

F. heteroclitus sperm radiated with 200,000 R wasn't affected.

- 1132 Rugh, R. 1949. Some prenatal effects of Amblystoma opacum larvae exposed to 25,000 R x-radiation. Anat. Rec. 103:500-501.

Deformed specimens were the result of irradiation.

- 1133 \_\_\_\_\_ and Helen Clugston. 1955. Effects of various levels of x-irradiation on the gametes and early embryos of Fundulus heteroclitus. Biol. Bull. 108(3):318-325.

Fundulus heteroclitus unfertilized eggs did not cleave. Males subjected to 200,000 R had viable sperm. Eggs fertilized with this sperm developed normally.

- 1134 Rushton, W. 1936. Biological notes, some experiments with fry. *Salmon and Trout Mag.* (82-85):57-67.  
Fry subjected to lethal doses of x-ray survive 6 weeks before death occurs.
- 1135 Rustad, R. C. 1960. X-ray induced dissociation of the mitotic and micromere "clocks." *Abstr. Biol. Bull.* 119(2):284.  
Sea urchin gametes irradiated produces micromeres at 1, 2 and 3 cleavage stages rather than 4th. The biological clocks that controls micromere formation is independent of division per se.
- 1136 \_\_\_\_\_ . 1960. X-ray induced mitotic delay in the *Arbacia* egg. *Abstr. in Biol. Bull.* 119(2):337.  
Radioactive sperm doesn't affect the mitotic delay, but extends the x-ray sensitive portion of the mitotic cycle which corresponds roughly to the early streak, the period of multiplication and separation of the centrioles.
- S
- 1137 Schuster-Wolden, E. 1936. X-ray studies of the intestine of *Cyprinus carpio* and *Tinca vulgaris* as a contribution to the problem of the significance of smell and sight in fish in the search for food. *Zeitschr. Fischerei* 34:245.  
These fish were x-rayed to show that BaCl<sub>2</sub> was picked up directly from the water.
- 1138 Smith, G. M. 1932. Eruption of Cortial melanophores and general cutaneous melanosis in the goldfish (*Carassius auratus*) following exposure to x-ray. *Am. Jour. Cancer* 16(2): 863-870.  
X-irradiation caused cancer of the tail in 5 days; entire body in 6.
- 1139 \_\_\_\_\_ . 1932. Melanophores induced by x-ray compared with those existing in patterns as seen in *Carassius auratus*. *Biol. Bull.* 63:484-491.
- 1140 Snider, G. and H. Kersten. 1935. The action of soft x-rays on Cladocera (*Daphnia magna*). *Phys. Zool.* 8:530.  
New eggs of *D. magna* disintegrated and in one day yielded distorted individuals. If the first instar was subjected to 45 KV, 10 millampat 3 centimeters from the focal point, death resulted.
- 1141 \_\_\_\_\_ and \_\_\_\_\_ . 1936. Susceptibility to soft x-rays of *Daphnia magna* during its development from eggs to young in the brood pouch. *Jour. Exp. Zool.* 74(1):1-6.  
If eggs 18-32 hours old were irradiated most survived. Eggs older than 32 hours all survived. A good study.
- 1142 Solberg, A. N. 1938. The susceptibility of *Fundulus heteroclitus* embryos to x-radiation. *Jour. Exp. Zool.* 78:441-469.  
A general study of *Fundulus* subjected to 4 increasing doses. The higher the dose the lower the sensitivity. The head and tail tip were the most sensitive.
- 1143 \_\_\_\_\_ . 1938. The susceptibility of the germ cells of *Oryzias latipes* to x-radiation and recovery after treatment. *Jour. Exp. Zool.* 78(4):417-439.  
Sperm of *Oryzias* were 3-4 times more sensitive to x-rays than the eggs; 1,980 R lasts for 23 days. The ovaries were reduced after a dose, but returned to normal shortly thereafter.
- 1144 Sonehara, S. 1933. Studies on the effects of x-rays upon the development of a pond snail *Lymnaea (Radix) japonica*. *Jour. Sci. Hiroshima Univ. Ser. B. Div. 1*:151-169.  
Growth rates were affected after irradiation.
- 1145 Spiedel, C. C. and R. H. Cheney. 1960. Comparative effects of x-ray and ultraviolet radiation of gametes on the developing sea urchin *Arbacia*. *Abstr. Biol. Bull.* 119(2):338.  
Damage was greatest after gradual x-ray dosages than UV exposures. An x-ray dose to sperm was equal to a dose of only 1.5-2X as much to eggs.
- 1146 Ssmokhvalova, G. V. 1935. Vliyanie rentgenovskikh luchei na polovuiu zhelezer i vtoricharye polovye priznaki *Lebistes reticulatus*. (The influence of x-rays on the sex glands and the secondary sexual characters in *Lebistes reticulatus*). *Trudy po Dinamike Razvitiia* (Trans. Dynamics Develop.) 10:213-229.
- 1147 \_\_\_\_\_ . 1938. Effect of x-rays on fishes (*Lebistes reticulatus*, *Ziphophorus helleri* and *Carassius vulgaris*). *Biol. Zh. Moscow* 7:1023-1024.
- 1148 Stone, R. G. 1932. The effects of x-rays on regeneration in *Tubifex tubifex*. *Jour. Morph.* 53(2):389-432.  
Normal regeneration in *Tubifex* is 35 days. This is inhibited if the specimen is subjected to x-rays.
- T
- 1149 Tanaka, P. 1942. (Influence of the ray of heliolamp upon the hatchability of *Oncorhynchus keta* (Walbaum)). *Zool. Mag. (Tokyo)* 54(8):313-314. (In Japanese).
- 1150 Tur, J. 1904. Malfomations embryonnaires obtenus par l'action du radium sur les oeufs de la ponle. *Comp. Rend. des Seances Tr.* 57:236-238.

V

- 1151 Vakrameyeva, N. V. and A. A. Neyfakh. 1959. Comparison of the changes in radio- and thermo-sensitivity during cleavage in the loach Misgurnus fossilis. Doklady Akad. Nauk SSSR.
- 1152 Vintemberger, P. 1928. Sur l'emploi des rayons X en embryologie comme agents de destruction localisee. Une technique nouvelle pour l'etude de la potentialite des deux premiers blastomeres dans l'oeuf de la grenouille rousse. Compt. Rend. Soc. Biol. 99 (33):1590-1592.

W

- 1153 Welandar, A. D. 1945. Studies of the effects of roentgen rays on the growth and development of the embryos and larvae of the chinook salmon (Oncorhynchus tshawytscha). PhD Thesis, Univ. of Wash. 131 pp.
- 1154 \_\_\_\_\_ . 1946. Studies of the effects of roentgen rays on the growth and development of the embryos and larvae of chinook salmon (Oncorhynchus tshawytscha). Univ. Wash. PhD Thesis, 128 pp. A. E. C. Rept. UWFL-2: 131 pp.
- Three lots of salmon eggs were subjected to x-rays of 25, 50 and 100 R. Those which were in the eyed stage hatched but showed signs of an effect for over a year. Most fry died in 30-51 days.
- 1155 \_\_\_\_\_ . 1954. Some effects of x-irradiation of different embryonic stages of the trout (Salmo gairdneri). Growth XVIII:227-255.
- 1156 \_\_\_\_\_ . 1955. Some effects of x-irradiation of different embryonic stages of the trout (Salmo gairdneri). Growth 18:227-255. A. E. C. Rept. (UWFL-38).
- A good report. Hubbs and Hubbs method is used to compare body proportions after irradiation.

- 1157 \_\_\_\_\_, L. R. Donaldson, R. F. Foster, K. Bonham and A. H. Seymour. 1948. The effect of roentgen rays on the embryos and larvae of the chinook salmon. Growth 12: 203-242.
- A very good study. List of effects on embryos are given. If subjected to 2800-10,000 R most larvae died in 30-51 days; 500 R had least pigment effect.
- 1158 \_\_\_\_\_ and F. G. Lowman. 1950. The effects of roentgen rays on adult rainbow trout. Univ. Wash. Appl. Fish. Lab. UWFL-17:1-7.
- Rainbow trout subjected to 1500 R yielded a 56% kill in 53 weeks, 87% in 64 weeks. Hemorrhages, neurosis, fungus and internal damage were the general results.
- 1159 Wichterman, R. 1959. Mutation in the protozoan Paramecium multimicronucleatum as a result of x-irradiation. Science 129:207-208.
- 1160 \_\_\_\_\_ . 1960. Production of viable races of Paramecium caudatum after micronuclear elimination with x-rays. Abstr. in Biol. Bull. 119(2):348.
- Repeated doses decreased or eliminated the number of micronuclei. Macronucleus is little affected by irradiation.
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