

.....,

,

,

.

.

.

,

,

.

.

-

-

-

,

.

(Maxwell, 1860),

,

-

(, , 1959).

-

,

,

,

.

-

:

,

,

,

,

.

-

,

-

.

-

，
(
)
，
« »
« »
« »
»
，

，
，
，
，
，
，
，
，
(
)

，
，
，
(100¹)

(Hering, 1905).

1856—1866

1

(Katz, 1930).

$$\Phi(\lambda) = \frac{F(\lambda)}{S(\lambda)} \quad (1)$$

1896).

« ».

(MacLeod, 1932),

(: ,) .

(Katz, 1930).

() (, 1971)

Maturana . , 1968; (Land, 1965;
Marr, 1974; , 1971 , ; Horn, 1974;
, 1974),

)

),

(

)

().

1. , : -
— -

, -
2. . -
.

3. (,
).

, -
.

, , -
.

, ,
4. , -
.

, , -
.

5. () ,
-
.

, -
.

: , -
.

, () -
.

(Katz, Revesz, 1921) (Köhler, 1965),
(Köhler, 1916)

(Burcamp, 1923)

(., 1972)

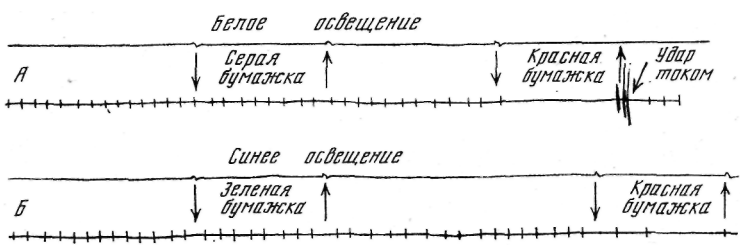
carpio L.)
(McCleary, Bernstein, 1959),

(Cyprinus

, ,
 ,
 (2×3)
 8×10) 15 (

100%-
 (,
 —), —
 ,
 ,
 ,
 ,
 ,
 ,
 (, - (-
)) ,
 ,
 (. 1). ,

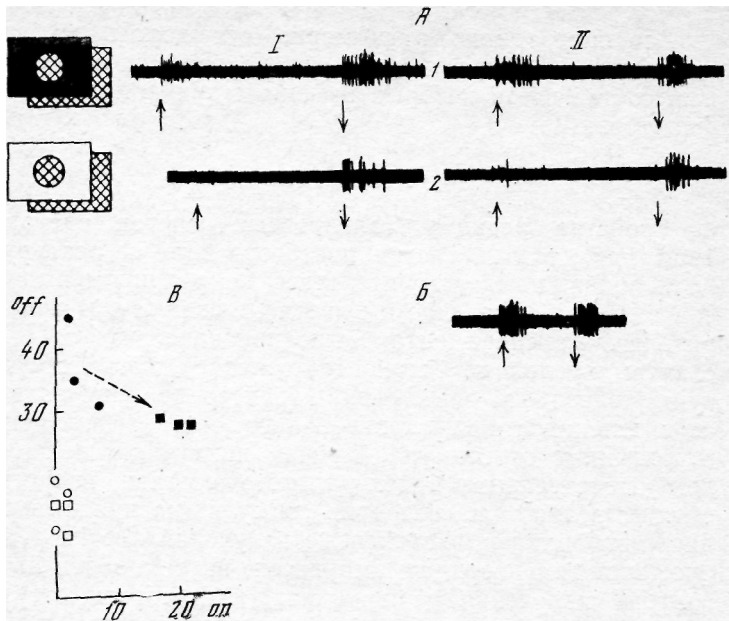
, , « »
 (., 1971). , « -
 » , (-
). , ,



. 1. () □
 — ; —

(1971 ,)

, . . . « -
 » , « -
 » -
 , . . . -
 .
 -
 tectum opticum , Caras-
 sius carassius L. Cyprinus carpio L.
 , tectum opticum
 . . . (1971).
 (,
) $5^{\circ} \pm 1^{\circ}$.
 :
 « » ,
 (10°), « » (,
), « » ()
 , (« »)
 ;
 (20 /)
 .
 10° ,
 ,
 « » , ()



. 2. ()
 —) , (I) (2) ; (I) (II) —
 — ;
 — () () .
 « () » ,
 2. —
 , —
 , —
 . , —
 « » — ,

3. , .

-

, -

, -

, -

4. () .

-

50 -

-

. 2. . 3 -

, (16).

-

-

-

-

-

, -

, -

-

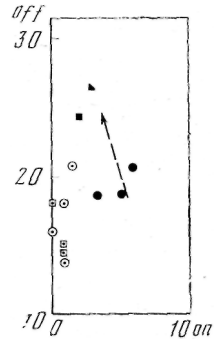
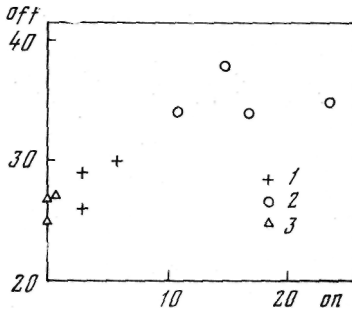
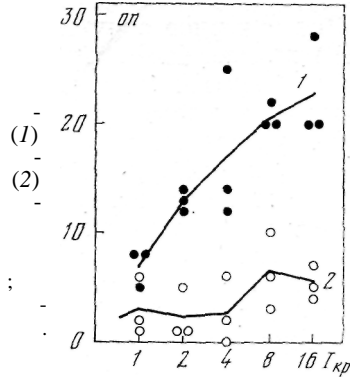
« ».

« »

(« » ,).

-

. 3.



. 4.

1 — ; 2 — ; 3 —

. 5.

) () (-
 , -
 -
 ()
), « »

() . ,

(. 4). -

. -

,

() ,

,

. -

, -

, (,

1971). ,

, -

, (, -

) , -

. , -

, -

, -

, -

: , -

, , -

. -

() , -

() , -

, (.5). -

, — , -

, -

, , -
 . -
 , -
 .
 ,
 (Wagner « . ., 1960; Daw, 1968a), -
 ,
 , (□
)
 . , (Daw,
 1968). , -
 (,)
 , .
 , -
 . (□
 ,
)
 .
 , -
 -
 .
 -
 (Brown, Major, 1966; Dowling, Werblin, 1969),
 :
 .
 , -
 -
 .

Dowling, 1969). (Werblin,

1969; Naka, 1971), (,

· , -
, -
, -

(,)

—
, -
, -
, -

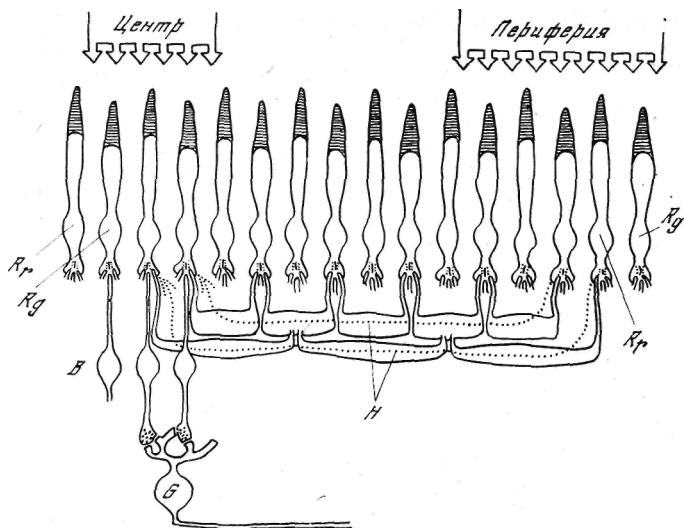
(Testa, 1966; , , 1973).

1967). (, 1968; Naka, Rushton,

(Stell, 1967; Stell e. a., 1975),
() —

(Svaetichin . . , 1965; Laufer, Millan, 1970; Stell . . , 1975).

¹ (, 1973) (Chan, Naka, 1976)



. 6.

. R_s R_r — ; — ; —
; G —

. 6

(). , -

, , -

, , -

, , -

, , -

, , -

, , -

, , -

() « -

» -

, -

(Katz, 1930; MacLeod, 1940). -

(, 1953). — , -

— , -

(., 1971). -

(1), , -

, -

—

· $F()$, —

(), , —

$S()$, —

—

:

$F() = S() \cdot () \cdot \cos .$ (2)

() , « »

$S()$, « »

$\cos .$

,

(R)

(G) :

$F^R = S^R \cdot R \cdot \cos ,$

$F^G = S^G \cdot G \cdot \cos .$ (3)

,

,

,

,

(),

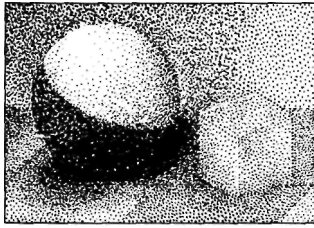
,

$F^R \cdot F^G$,

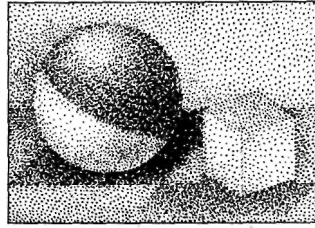
,

(3).

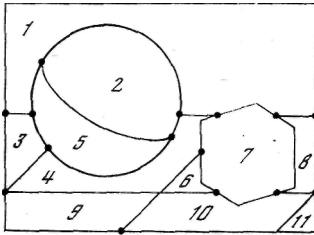
, , -
 , , -
 , (, , -
). , -
 , , -
 , -
 . , -
 , -
 , -
 , -
 . , -
 , (1974);
 (. 7). (, , ,)
R *G*) (. 7, ,).
 (. 7,), , -
 -
 (. 7,), — -
 -
 (. 7, ,), (. 7,).
 , , -
 , -
 (, ,), , -
 . , -



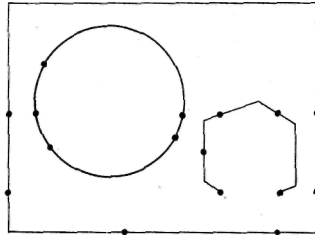
a



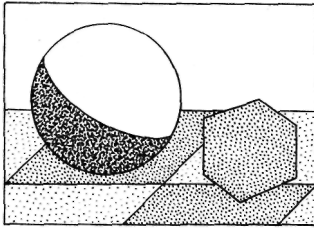
б



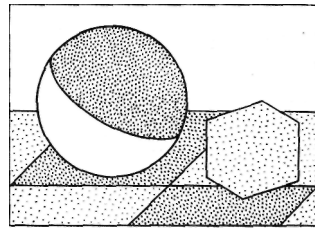
в



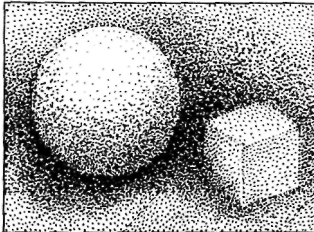
г



д



е



ж

. 7.

: - « » , - « » : - 11 -
 , - : - « » , -
 - « » ; -)

, - , (-
 ,), - , ,
 - , , -
 . , -
 . ,
 , , -
 , , -
 « »
 — « ».
 (2), -
 , -
 , -
 , , -
 =0 , cos =1). (-
 , ,
 ,
 . cos
 , , ,
 . ,
 , —
 . , (3),
 -
 -

cos). (-

« » cos .

1, . -

: 1) () -

; 2) , -

¹ (1975). (1974) . -

, , -

, (, , -

), , -

, , -

, . , -

, , -

. , -

, , -

:

, , -

, , () -

. , -

, , , -

. , -

(, -) , -

. , -

, , -

, , -

, , -

, . -

(, 1953).

.

.

(, ,)

,

.

(

)

,

{

},

)

— , (, ,

,

.

:

— , , ,

,

(

)

(« , , 1974).

»

,

(, 1950).

,

,

,

,

()

(Hartline, 1934).

()

(Daw, 1973).

)

(

cos

cos

(Horn, 1970; .., 1975).

)

50

» (Parsons, 1924).

) — (, , (Daw, 1973), -
—) (-
) - -
,

’ , -
,

« » , , -
,

« — » (Thayer, 1896).

, ,
, .
,)

- , ,
(),

(, , ,
, .). (,
)

, ,
,

« » (r -
uss, 1928).

(Bender, Ruddock, 1974).

, , -
-
, . ,
, ,
, . , (: -
) : -
-
, , -
, , -
, . , , -
, () ,
— .
» , « — -
» , , -
« » () , -
, , -
, . -
— -
, . -
— -

(,)
555 445 (Daw, Pearlman, 1969).

(Sechzer, Brown, 1964; Meyer, Anderson, 1965).
(Granit, 1947) (Pearlman, Daw, 1970),

), (

1. ,
, , ,
().

2. -
3. - , : -
- , , -
- , ,
- , ,
- . . . 1959. -
- . — , 5, . 13—20.
- . . . 1896. — , 3, . 86—94.
- . . . 1975. , 20, . 725—730.
- . . . 1972.
- 22**, . 772—779.
- X. 1950.
- . . . 1975. „ .
318. — , 20, . 313—
- . . . 1965. — , 6,
- . 58—62.
- . . . 1968. „ . 247—248.
- . . . 1974. „ , 19, . 151—167.
- . . . 1969. -
- . — , 14, . 537—543. -
- . . . 1971. -
- „ **11**, . 892—899. —
- . 1968. „ .
- . . . 1953. -
- , 8, . 128—134. —
- . . . 1971 . I. -
- , 16, . 285—293. -
- . . . 1971 . II. -
- „ — , 16, . 1052—1063. -
- . . . 1973. -
551. : — „ , 52, . 541—

- Bender G., Ruddock . . .* 1974. The characteristics of a visual defect associated with abnormal responses to both colour and luminance. — *Vision Res.*, **14**, p. 383—393.
- Brown J. E., Major D.* 1966. Cat retinal ganglion cell dendritic fields. — *Exptl Neurol.*, **15**, p. 70—78.
- Burcamp W.* 1923. Versuche über Farbenwiedererkennen der Fische. — *Z. Sinnesphysiol.*, **55**, S. 133—165.
- Chan R. Y., Naka K.-I.* 1976. The amacrine cells. — *Vision Res.*, **16**, p. 1119—1129.
- Daw N. W.* 1968a. Goldfish retina: organization for simultaneous colour contrast. — *Science*, **158**, p. 942—944.
- Daw N. W.* 1968b. Colour-coded ganglion cells in the goldfish retina: extension of their receptive fields by means of new stimuli. — *J. Physiol. (Lond.)*, **201**, p. 745—764.
- Daw N. W.* 1973. Neurophysiology of colour vision. — *Physiol. Rev.*, **53**, p. 571—611.
- Daw N. W., Pearlman A. L.* 1969. Cat colour vision: one cone process or several? — *J. Physiol. (Lond.)*, **201**, p. 745—764.
- Dowling I. E., Werblin F. S.* 1969. Organization of retina of mudpuppy, *Necturus maculatus*. I. Synaptic structure. — *J. Neurophysiol.*, **32**, p. 315—338.
- Granit R.* 1947. Sensory mechanisms of the retina. London, Oxford Univ. Press.
- Hartline H. K.* 1934. Intensity and duration in the excitation of single photoreceptor units. — *J. Cellular and Compar. Physiol.*, **5**, p. 229—247.
- Helmholtz's treatise on physiological optics. Transl. 3rd germ. ed. (1924). J. P. S. Southall (Ed.). N. Y., Dover Publications.
- Hering E.* 1905. Grundzüge der Lehre vom Lichtsinn. — In: Graefe-Sämisch Handbuch der gesamte Augenheilkunde. Th I, Bd. III, Cap. 13.
- Horn . . . P.* 1970. Shape from shading: a method for finding the shape of smooth opaque object from one view. — MAC TR-79, MIT.
- Horn . . . P.* 1974. Determining lightness from an image. — *Computer Graphics and Image Processing*, **3**, p. 277—299.
- Kaneko A.* 1973. Receptive fields organization of bipolar and amacrine cells in the goldfish retina. — *J. Physiol. (Lond.)*, **235**, p. 133—153.
- Katz D.* 1930. Der Aufbau der Farbenwelt. Leipzig, Barth.
- Katz D., Revesz G.* 1921. Experimentelle Studien zur vergleichenden Psychologie. — *Z. angew. Psychol.*, **18**, S. 307—355.
- Köhler W.* 1916. Die Farbe der Sehedinge beim Schimpansen und Haushuhn: — *Z. Psychol.*, **77**, S. 147—177.
- Krauss S.* 1928. Tatsachen und Probleme zu einer psychologischen Beleuchtungslehre auf Grundlage der Phänomenologie.— *Arch. ges. Psychol.*, **62**, S. 182—211.
- Land E. H.* 1965. The retinex. — In: CIBA Foundation Symposium on Colour Vision. London, Churchill, p. 217—223.
- Lauffer M., Millan E.* 1970. Spectral analysis of L-type S-potentials and their relation to photopigment absorption in a fish (*Eugeres plumieri*) retina. — *Vision Res.*, **10**, p. 237—251.
- MacLeod R. B.* 1932. An experimental investigation of brightness constancy. — *Arch. Psychol.*, **21**, p. 102—135.

- MacLeod R.* . 1940. Brightness-constancy in unrecognized shadows. — *J. Exptl Psychol.*, **27**, 1—22.
- Marr D.* 1974. The computation of lightness by the primate retina. — *Vision Res.*, **14**, p. 1377—1388.
- Maturana H. R., Uribe G., Frank S.* 1968. A biological theory of relativistic colour coding in the primate retina. — *Arch. Biologia Medicina Experimentales*, Suppl. N 1, p. 1—30.
- Maxwell J.* . 1860. Theory of compound colours, and the relations of the colours of the spectrum. — *Proc. Roy; Soc. London*, **10**, p. 404—409.
- Maxwell J.* . 1872. On colour vision. — *Proc. Roy. Inst. Gr. Brit.*, **6**, p. 260—271.
- McCleary R. A., Bernstein J. J.* 1959. A unique method for control brightness cues in study of color vision in fish. — *Physiol. Zool.*, **32**, p. 284—292.
- Meyer D. R., Anderson R. A.* 1965. Colour discrimination in cats. — In: CIBA Foundation Symposium on Colour Vision. London, Churchill, p. 325—339.
- Naka K.-I.* 1971. The receptive field mechanism in the vertebrate retina. — *Science*, **171**, p. 681—683.
- Naka K-L, Rushton W. A. H.* 1967. The generation and spread of S-potentials in fish (Cyprinidae 7). — *J. Physiol. (Lond.)*, **192**, p. 461—473.
- Parsons J. H.* 1924. An introduction to the study of colour vision. Cambridge Univ. Press.
- Pearlman A. L., Daw N. W.* 1970. Opponent color cells in the cat LGN. — *Science*, **167**, p. 84—86.
- Sechzer J. A., Brown J. L.* 1964. Colour discrimination in the cat. — *Science*, **144**, p. 427—429.
- Stell W. K.* 1967. The structure and relationships of horizontal cells and photoreceptor-bipolar synaptic complexes in goldfish retina. — *Amer. J. Anat.*, **120**, p. 401—423.
- Stell W. ., Lightfoot T. G., Wheeler T. G., Leeper H. F.* 1975. Goldfish retina: functional polarization of cone horizontal cell dendrites and synapses. — *Science*, **190**, p. 989—990.
- Svaetichin G., Negishi K., Fatehchand R.* 1965. Cellular mechanisms of a Young-Hering visual system. — In: CIBA Foundation Symposium on Colour Vision. London, Churchill, p. 178—203.
- Testa A. S., de.* 1966. Morphological studies on the horizontal and amacrine cells of the teleost retina. — *Vision Res.*, **6**, p. 51—59.
- Thayer A. H.* 1896. The law which underlies protective coloration. — *Auk*, **13**, p. 124—129.
- Viaud G.* 1960. La vision chromatique chez les animaux (sauf les insectes). — In: Mechanisms of colour discrimination. London, Oxford, N. Y., Paris, Pergamon Press, p. 41—57.
- Wagner H. G., MacNichol E. F., Jr., Wolbarsht M. L.* 1960. The response properties of single ganglion cells in the goldfish retina — *J. Gen. Physiol.*, **43**, Suppl., 2, p. 45—62.
- Werblin F. S., Dowling J. E.* 1969. Organization of the retina of mudpuppy, *Necturus maculosus*. II. Intracellular recording. — *J. Neurophysiol.*, **32**, p. 339—355.