-2 94 R. Sperry

Animal behavior Examination on Jennings October 1939

I. Check the correct answers to the questions.

1) Weber's Law states:
   a. All behavior can be reduced to a series of simple reflexes.
   ✓b. A perceptible difference in sensation is caused by a relative rather than an absolute change in the environment.
   c. Behavior under stimulation depends upon the normal life processes of the animal.
   d. A relative rather than an absolute change in stimulus intensity causes a reaction.

2) When two stimuli are operative at the same time, Paramecium maw react in which of the following ways?
   a. It may give a new reaction not ordinarily caused by either stimulus alone or by any other single stimulus.
   b. It may react to the more effective of the two stimuli and disregard the other.
   c. It may exhibit behavior which appears to be a compromize between the usual results of each stimulus.
   d. It may exhibit erratic behavior and react to each stimulus in turn.

3) Jennings' definition of behavior is:
   a. Actions which can be modified with repetition.
   b. Reactions to external stimuli.
   c. Conscious behavior
   ✓d. Reactions to external stimuli and physiological states.
   ✓e. General bodily movements of animals.

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4) The most noticeable physiological states of the lower animals are those which depend on:
   a. Changes in temperature
   b. Changes in orientation
   ✓c. Changes in metabolism
   d. Changes in lighting conditions

5) Most protozoan behavior described by Jennings falls into the following catagories:
   a. Learned
   ✓b. Unlearned
   ✓c. Trial and error
   ✓d. Adaptive
   ✓e. Simple reflex
   f. Conditioned reflex

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6) Which of the following animals are photopositive?
   ✓a. Euglena viridis
   b. Paramecium
   c. Stentor coeruleus
   ✓d. Green Hydra

7) Which of the following Phyla best demonstrates independent reflexes by the behavior of its members?
   a. Coelenterates
   b. Echinoderms
   c. Protozoa
   d. Platyhelminthes

8) Which of the following movements represents the essentials of the action system of Paramecium?
   a. Vertical movement
   b. Forced movement
   c. Revolution on the long axis
   d. Forward movement
   e. Movement toward food
   f. Swerving toward the aboral side.

9) Contraction of the entire body by Hydra is the usual reaction to which of the following stimuli?
   a. Carbon Dioxide concentration above the optimum
   b. Water currents
   c. Weak light
   d. Constant electric current
   e. All sorts of intense stimuli

10) The behavior of any animal at a given moment is dependent upon which of the following factors?
   a. Weber's Law
   b. Harvard Law of Animal Misbehavior
   c. Former stimuli
   d. Present external stimulus
   e. Psychic states
   f. Former reactions of the organism
   g. Laws of the resolution of physiological states.
   h. Subjective interpretations of the observer.
   i. Progressive internal changes in the organism.

(The following are essay questions to be answered as briefly as is consistent with an adaquate treatment of the material.)

Select and answer any two questions.

I. Make an outline classification of types of stimuli using the protozoan reactions as criteria; i.e., classify stimuli according to the types of reactions they evoke. Give an example of each type of stimulus and its reaction.

II. Using the evidence presented by Jennings, discuss the essential differences between the behavior of the Protozoa and that of the lower Metazoa. Are these differences qualitative, quantitative, or both?

III. By repetition of a stimulus it is possible to modify the reaction to that stimulus by a protozoan individual. Describe this phenomenon in a protozoan of your own choice. What, of objective importance, can be inferred from this phase of behavior?

II. The behavior of protozoans does not differ in essence or quality from that of the lower metazoa. Every type of reaction shown by the lower metazoans to the various types of stimuli is also illustrated by the protozoans tho in a somewhat less complex degree. The three essentials of behavior:—(1) its dependence on the relation of internal to external conditions with modification occurring to a change in these conditions (2) the selection from among varied conditions resulting from over-produced movements (3) and the more easy and rapid resolution of one physiol. state into another after repetition are all seen in the protozoa as well as in metazoa. [(1) & (2) are too obvious to describe and (3) will be illustrated in answer to III.] The protozoans react to mechanical chemical light, temperature and electric stimuli which include all classes of S. to which the metazoans react. Jennings' emphasis in comparing the behavior of the two is on their similarity, not difference.

Therefore the main differences are of degree only. The structure (single cell) of protozoa necessarily results in a different form of reaction from that of the many celled animals with various independent parts. For example the hydra with its tentacles, mouth & trunk systems all of which may react independently, shows a more complex degree of beh. than the protozoans, as with that "repetition of reflexes" the sea urchin. Tho the law of resolution of physiol. state applies to the protozoans (stentor), it is found that the

change in behavior lasts longer in Spirostomum (Verbeck 14 days) than it does in Stentor. According to Jennings it is erroneous to think that the behavior of protozoans is more stereotyped and invariable than that of the metazoa. "Indeed, the appearance of a nervous system does not bring with it any essential difference in behavior, the difference is still one of degree. The coelenterates show the same characteristic unbalanced choice as the protozoa, one with a nervous system the other without. The nervous system merely integrates and harmonizes the activity of the parts.

III

When carmine grains are applied to Stentor it at first does nothing, then it bends away, then if carmine is still applied, the Stentor severs the head of its cilia. If this does not clear away the carmine, the Stentor contracts. After a while it will relax again with cilia beating normally and if there are still carmine grains coming in, it may begin to contract violently and throw off another portion.

No light contact Stentor may contract to first stimulus but not later ones. No stranger. Contract to stimuli it. may contract 5 or 6 times then cease then start again with intervals of non-contraction growing longer.

This shows a change in behavior to a constant external stimulus which means there must have been some change in the organism. This change in an organism as the result of experience is the essential factor in the learning & memory of higher forms which constitute one of the main problems of animal behavior in the higher forms. It would be extremely important if this change in Stentor were essentially the same as that which occurs in the conditioning of higher forms — differing only in degree, length of time, etc as Jennings suggests — in that the problem could be studied in these more simple forms rather than in the complex sympathetic nervous systems. I state that the change is merely physiological not anatomical — would be interesting if same were true of higher forms. Also it is interesting & important in itself that this factor can be found right down to the protozoan forms.

Jennings' Beh. of Lower Organisms

Amoeba

Both ectosarc and ectosarc roll. shown by pieces of dust etc.
Pseudopodium rolls also if it's in contact.

In some amoeba currents flow back in middle. On surface away from pt. of lowered surface tension.

Most amoebae do not move at all as do liquid drops where most ∴ produced thru ∆s in surface tension.

1) Amoeba-verrucosa — move slowly no ∆ in shape
2) " limax — " faster ∆ form, but no pseudopodia
3) " proteus — " w. many pseudopodia.

Reactions 58m

Contact w solids ⊙

Needle, ~~part touched contracts, & current flows to one side~~ strong S may make it reverse.
Can guide an amoeba where want to by repeated S.
S of post. end doesn't ∆ course, may speed it a little.
When pseudopods fork, then one or other drains its cytoplasm
Fish in all directions when it hangs free in water.

No 2 Chemical, 3 Heat, 4 Light, & 5 Electricity

Chem — contracts, releases from substrate & starts in new direction. any water diff'l from that to wh it's accustomed causes negat. Rn.
heat - neg. R.
light - " " to strong light, a spot of light on pseudopod causes no R.
elect. - moves to cathode as if S on outside side.

seems to pursue an elusive fragment of food.
Does not ingest other particles, bodies that chance to stick to ectosarc.
R's to all classes of S to which higher animals R. mech, temp. light chem. & elec.
to ∆s in environ. or in selves.

Direction of R. determined simply by part S'd. It's this part that R's primarily. New pseud. goes out as if to least resistance as a continuation of old main.

Past R's & present effect conditions within an's body determine direction of movement.

Position of new pseudopod determined by internal conditions, not by ext. S & ∴ it's a "trial" Rx. (?)

S induces movements in various directions & one is selected because it relieves the S'n. "selection from among the conditions produced by varied movements" [where does selection come in?]

Three types of R'n: ⊕, ⊖, & food are not stereotyped.

Invisible factors enter — so can't predict amoeba's Rx from knowledge of external factors alone.

Says food Rx's are not purely reflex. because Rx to an escaped predominantly ingestive. amoeba is diff't from ud because of past expce.

Modifics of Rx's due to acclimatization, & to interfer of S. light of the ingestive food light & effec.

Bacteria less simple than amoebae, nearer plants in animals?

move by whipping flagellae & cilia

starts off in direct'n of longit'l axis, some have a-p diff'n.

reverses continually in long axis in swimming.

of contact reverse motil for moment, stay reversed if have flagellum at both ends. same for chem's acids alkal's.

positive Rs to air bubble, green plants food etc. → collect by means of negative Rx's also — by accident gets into favorable area, can R'te expeditiously small units of O_2. each species adapted to an optim. conc. same fact evident in all kinds of chem's that could hardly be called adaptive R's.

some chem dilute — +R, strong — −R.

" heat + & light some — & kinds same as contact + chem R.

swarm diotaxis of " puts em in reverse. react to colored light same way in ultra red heat, collect & metabolize best.

temp & effect. not studied much, gravity, often settle down when contact solid obj.s.

— Here a single motil, simple as reflex action, diff't parts of body don't have to be so diff'td as in amoeba. R. to a negative Δ in environment + Δ only speeds motil. Strength of Δ f's Weber's law. relative Δ not absolute

Bacteria (cont.)

variatns in same species & even same culture. same indiv. may go off diff'ly. Behavior under S depends on the nature of the normal life processes - (metabolic processes)
Bhr that results in interference w. normal metabolic processes is changed, mov't being reversed while other bhr is continued.
Direct'n swim depends on long axis
Bhr based on the "selection from among the conditions produced by varied movements."

Infusoria - Paramecium

Cilia beat obliquely and so cause animal to rotate on its long axis. "can" in many diff't directions. Rotation is over to left both backwards & forwards.
Cilia in oral groove beat more strongly than those elsewhere.
3 factors produce spiral course:

variation of these 3 factors — bhr < {
cilia strike backwards → forw. mov't
" " little obliquely → rolling
" stronger in oral region → swerving toward aboral side.
}

rotation enables it to ff. a straight course.
beat of oral cilia allows p. to sample water ahead of it hyperaglltr more active than amoeba.

"avoiding Rn" - goes into reverse, before start'g forward, revol. on long axis slows, swerving increases & pivots on its tail sampling water from diff't directions till a satis. sample sends it forward again.

Diff't phases of the avoid'g Rn differ acc'd to circumstances. "varies greatly under diff't conditions" diff't intensities of S's. may merely stop, or reverse twice usual distance & swing in large circles. to swing away carefully & start in greater

Sq cants act same whether hit whole body or just ant. end but to constant condit'ns soon becomes acclimatized. It's the Δ that counts. Has to be Δ in one direction. NaCl → HCl higher → no Rx lower

In anod-R the animal always turns toward aboral side regardless of wh. side is S'd.

Positive Rins: = anod Rin Paramecia gather in distilled H2O in preference to their natural pond water.
Swim at random, no Rin on entering drop of favorable fluid, but on abundance Rin prevents leaving.
Slightly acid is favored over distilled H2O ~ 6.8%

Natural condition of animal is anod.
Ant. end & about mouth is more sensitive than elsewhere.
*Mech Son middle & rear end cause animal to move forward rather in anod-Rin.

Sometimes & same indiv.s inclined to come to rest against objects they strike, after one weak anod Rin. Cilia in contact become stiff and set. Meanwhile ordi groove cilia keep in active motion. other cilia strike weakly.
When hit a small object not heavy enough to anchor, then swim around in wide circular motit.

Rin to osmotic pressure occurs too late to aid them. also acids
It is not the injuriousness of chem.s Only that causes Rin, but the chem. prep. Some chems S enough to warn, other don't.
But injury does cause avoidance Rin when chem. becomes strong
It's a step toward less optimal conditions that produces R. esp.
P. gather in CO2 acid they form so gather in clumps accidentally. the group gradually enlarges & spreads out
Optimum temp = 24-25°C p detects a diff of 3°C.
Orientation & location idle. all brought about by exclusion. trial & error.

Rin to Light: no Rin to light except to powerful ultra-violet light. avoiding Rin.
To water currents, gravity, & centrif. force the orient axis taught in anti end up. Produced thru avoiding Rin. Water current Rin occurs only when there is heterogeneity of current.
The contact Rin inhibits the gravity Rin. Gravity Rin due to fact that animal has substances of diff'l specific gravity in him.

Paramecium (cont)

Must own S will overcome gravity Rn.

The avoiding Rn brings:
1) Diff'l direction of mvmt
2) Diff'l axial position
3) " environmental conditions

so no direct causal relation in release of disturbance & method used to release. The Rn is a genetic quirk & not one of organic principles of Paramecium

Rns to Elect.:

swing toward cathode, ff. lines of force

In strong current stop and then begin toward anode, if current still stronger, they burst.

trichocysts thrown out if current strong.

there is a summation effect of repeated (induction shocks, a series causing a Rn whereas one alone is insufficient.

cilia at front end are not reversed in weak current — can get to body striking one way, other half the way. increase current still further & all reverse & p. goes back toward anode.

~~when animal is transverse to current, cilia on each side~~ beat in such way as to turn ant. end toward cathode.

happens even when oral side directed " " (which never happens w. any other S.

Det. indep. & opposing effects of cilia in diff't parts of body wh. never " " " " .

Sometimes they swim in transverse direction if current is rapidly reversed. Cause anter. end is least affected, cause it turns to this position, ant. end swings around ~~greatest effect when~~ it's not transverse.

Will collect in current-free areas — no trial & error.

All peculiarities due to cathodic reversal of cilia.

Slight basal contrns of cilia are seen, but not known how they are produced.

Saturated solution of picric acid cause trichocyst discharge & certain fatal S also.

Induction shocks ant. end, a-p pol, all over if strong enough.

Not known of what use they are.

Param. still cont.

2 or more stimuli:

may R to more effective of 2 or may make a compromise R.

~~contact~~ negative + geot. = no R. if not very strong

" " heat = " " until 7°C higher.

heat & cold interfere w. contact R.

contact + chem. = R less readily.

& chem. prevent contact R's. (CO_2 favors contact R)

" prevents gravity R

" & elect. = requires 4 or 3 times stronger current (cilia move then

current + contact = if weak contact may win. give alternately

takes up transverse position cilia backward

reread >

if current reversed, turns 180°.

The R to gravity always gives way to other R's.

Sometimes depends wh. S starts first

" R = a resultant of the 2 stimuli.

Modifiability

1 S first, then R diff'ly to 2nd: (slight beginnings of the modif. of R thru previous experience)

diff's between cultures

p fails to react to weak induction shocks after a strong one.

Summation.

Acclimatization

Hunger, fatigue

Sudden jarring causes im to swim downward for some time

Also little sign of fission (conjugation two oral cilia stick each other together oral surfaces become viscid) conj. behave as usual.

Action System

spiral course w. 3 factors

variat.s in these produce avoid'g R's. contrac. of ectosarc discharge of trichocysts

positive contact R's!

so each kind of S does not have specific effect — merely sets off these few R's. many diff. S produce same effect. In study'g ber. most imp. step is to work out action system of org. test of movt.s

movt of Δs animal meets due to this known movt.

R's ceases when S's removed.

Jennings (4)

Rhi of other Infusoria:

Most infusoria swim in spiral. & when S'd turn towards a certain side

Flagellata draw cone of H₂O in w. flagellae & keep same side of body out in spiral swimming

Chilomonas:
turns on long axis & rests w. one flagella as anchor
avoiding Rh somewhat ~~[illegible]~~ of p. "tries" diff. directions.

Euglena
avoid. R. a b. . . .
to intense S contracts into sphere & begins to encyst.

Ciliata -
back up & turn to a specific side
also to strong S give marked contrns of body.

Hypotricha - creep on special modified cilia.
produce a vortex to mouth
don't revolve on long axis, back up & start forward on a specific side.

Rhs are less flexible in creeping than in free-swimming ciliata.

Even attached forms may break free and act like p.

Mechan S.
contact = + or -
turn toward aboral side regardless of which side is S'd, so the direction of movt in the Rh depends on R. mechanism, not point of Sn. (except when hit rear end).
Stentor will bend to any side to ff. a piece of soft mater. (food)
Rhs modified when animals in contact.

Chem. S
collection tendency for a certain solution depends on solution in wh. they've been.
collect in solution in wh. they're least repelled.

Light: colored ones R markedly to light + or -.
(-) Stentor: swim away from source does it by avoidg R. as goes in ⊙s. So ant. end no longer subjected to Δs in illumination.
why not toward light?
(+) Euglena: swim toward light in spiral. to sudden decrease in light, they stop and swing in circle, degr of circle depends on strength of S.
due to decrease in light, not due to direction of rays.
most + to blue light.
Sunlight = too bright, shadow too dark, so gather at band between.

both + & − R's due to avoid'g R'i.
most colorless infusoria don't R to light, just those to wh. = advantageous.
If Δ in light is very gradual, there's no R'n.

Ri to Gravity: up.

Ri to Electric Current

cilia of cath region strike forward, anode backward.
induction shocks: avoid. R, contraction of an- contractile, least affected when in transverse position
constant current: euglena same, some toward ca, an, or transverse.

rev.

+ Summary

Chap X Modifiability:

Stentor: jet of H2O causes it to contract only the 1st time. slight jar does same.
(% strong S continue to R. for long time) so not fatigue of motor
If use glass rod, may contract a half dozen times, & then just bend out of way — so again = Δ in behavior.
= regulatory bhr ≠ to higher animals. ∴ not fatigue of sensory
If use stronger rod S, may R ¼ doz. times stop, then start again for ½ doz. times, etc. interims become longer. (possibly fatigue)
Carmine particles, rotates out of way — or reverses cilia a few times, then contracts & comes back w. cilia beat'g OK
If carmine still applied now, contracts at once, repeats again & again 10-15 mins ~~times~~ & finally contracts violently to break loose from its tube
forms new tube by secret'g mucous while making oscillatory movt's same
Sometimes steps are left out and the sequence is otherwise varied so can't explain any one R'n by saying the preceding was essential & causative. Any step depends on ineffectiveness of preced'g step to remove the S'i.

Modifiability (cont.)

Rh differs to same situation. So the Δ in R must be due to a change in the organism. The physiological state of the organism has changed. No ordinary Δ.

The modification lasts only a short time. But the Ri depends on past experience, & is regulatory. so = same as learning in higher animals, same less complex & lasts a shorter time.

This is simplest & least varied in pre-swimmers. (cf. crawlers & static)

No rest period of inactivity

Δ of Rhi at conjugation may be due to Δ in physiolog. state.

Part II Rhi of Lower Metazoa

Coelenterata: Motion System bends in any direction

Hydra keeps up rhythmic activity. = spontaneous contractions, Hydra changes its attachment quite often. Locomotes like a measuring worm, or glides on foot.

Medusa fish w. tentacles, sting food

Hydra shows right Ri (to rest to gravity). Tendency to get into a normal position w. head free, foot attached body straight etc.

Many satisfactory conditions to keep animals in one spot, but no one is absolutely necessary (unless it's having head free). It depends not on a complex S, but on maintenance of physiological state.

Sea anemone clings & shrinks to crab's back.

No intense S - get contraction of whole body whether S is at head or foot. Temp or mechan.

Localized R. - contraction to local chem., heat causes bend ← w. bringing tent. into Sg region. Localized injury contrac. lasts long after S removed. Anemone & medusa also

Medusa bell: If margin or outer surface S manubrium bends over and touches tip to point S. Loeb explains as mere spreading of local contrac. But manubrium makes trials if a "cut" placed in bell, so Loeb's explan. doesn't hold. Failure Δs physiol. state so tries a new direction.

Rejecting Rx of Sea Anemones

Removal of collected waste on disk. Tentacles relax, become thin, & disk surface stretches & water movement washes loose cells off smooth surface. If not disk sinks in the region, or begins to swell making rounded elevation, etc. Whole Rx shows flexibility and variability.

Locomotor Rx in Hydra & Sea Anemones:

On getting under from dist. S hydra is just as apt to move toward that side as away from it. Either in bending or in shifting its attachment. Jumpers, leaf, mechan. S etc.

Sea anemones: S a tentacle contracts & extends again in same direction, keep on & after a while will extend in a new direction, keep up & will extend in still new direction. Keep it up & finally it will release foothold & move to new position.

Aiptasia because of crevices etc often extends in crooked manner, when removed, will often extend in same "way. = habit but may be growth factor. Can change a left bend to a rt bend, by one extension. (habit) In contracting it retains some of its bended form so extends out same way again.

Sea anemones daily always act same way to natural ext. S. Bad experience suppresses Rx.

Acclimatization to S: slightS get a few Rx, then they cease.

Rx's to Electricity (constant elect. currents) induction & same as injury

Hydra contracts on anode side, tentacles in line w. current contract so "" bends toward anode then whole body contracts. If attached by head = reverse so orientation due to local contractions.

Rx's to Gravity: point = of body & dir. of locom in same nor. factors causing " " Light : many dark, some do (maybe)

Hydra: collect in light espec. blue light trial & error, random. Tendency to keep ant. end toward light feats small crustacea & other minute animals with pp. light

Convolvuta: much less active in dark than in light, in strong sunlight first rises to surface, then later goes down, gets bit frantic & tend to start toward light, then become acclimated. Rx of a resting medusa to ↓ of light - variable. No's gather in shaded regions.

Rx of organisms and events simple S. depends on a multiplicity of factors.

To Food: chances depend on physical factors. On contact, nematocysts shot out & tentacles bend to bring food into mouth, mouth opens wide & lips work up over food, tentacles release it. Take large objects.

Chem. sets off cnidocil of nematocyst. Only hungry Hydras eat.

a combin. of chem + mech. S is necessary to set off food Rn. unless very hungry when chem alone will do. Hungry ones move about, if catch no food, sink to bottom & engorge mud.

Medusae seizing moving mats., chem. S set tentacles into action nearest it. If no find get contrn wh. may take an. nearer or farther from the food. Tentacles wrap about food & draw it to mouth.

When Rn may be produced by chem S. alone.

When tentacles merely touched w. rod or needle, contract straight away but " " rubbed right " " contract as if for food. (twist manubrium bends)

Rn time to moving object = quicker than to immobile one.

Sea anemones: usually sit & wait, but may swing tentacles about actively. Small inorganic particles falling on tentacles are carried outward, food particles carried inward. Cilia in oesophagus also reverse & carry food inward. Swallowing movt's by M's around mouth.

Very hungry ones swallow indiff't bodies, overfed ones won't eat but refuse food. The full Rn depends on metabolic processes, not just distension of the body. Cause filter paper will be purged + gorged & disgarded & purged again.

Hungry specimens = more active and more sensitive.

Single tentacles after repeated S will refuse to take food, tho the other " will.

A specimen may refuse paper. But take it if preceded by meat.

Indep. & Correlatn of Bhr of diff't parts of body:

Tentacles Rn as autonomous units when cut off body or transp'd elsewhere.

Isolated manubrium swallows food.

" centers & margins of bells contract rhythmically.

But one part of body may R & other S in another part. + Jennings stresses idea that Rn is integrated in intact animal. It's not a collection of indep organisms.

Coelent. Bhr of'd: not radically diff't from protozoa — varied movtom select. food reaction systems, dep. on physiol. state, (most imp't) past Rns & S.

Rs in other metazoa

Def Rs forms: Reflexes - even these = variable when studied in detail

Sea urchin Rs = largely of reflexes: motor organs scattered over surface. Spines & pedicellaria, cilia, & tube feet. — all connected by network of nerves, one on outer surface, one on inner surface of shell canals w. 5 radial n. trunks to n. ring at center.

Each organ may act as def. indiv. w. its set of reflexes. Each organ acts about same when isolated.

But n. syst makes 'em work in harmony = a republic of reflexes no central unity.

Planaria's system of Rs described. Turns toward lights, away from strong ones. Prisms = forced marches & cannibals. Instincts = more complicated chains of Rs. Instincts - more adaptible & variable than formerly supposed.

(a widespread impression that Rs in lower forms is stereotyped & machine-like & Rs in higher forms is evanescent. (J.)

Rs by Varied Means w. Selection from Resulting Conditions.

Echin. = best ex. of an's where Rs = more or less indep. Rs, but even these have variable Rs.

Rs of sea urchin & righting R. of starfish very variable. Tube feet that attach seem to 5 other & keep not finder. Brittle star removed a tube placed over its form by many diff't attempts.

Preyer claims that a starfish is able to free itself from constricting pins more quickly as a result of previous exp'ce.

Rotifera act exactly like infusoria in most respects - reverse toward dorsal side.

J. vs. tropistic theory

Varied means w. subject animal to diff't conditions

Planaria's Rs to drying. worm head around. Before death tries every Rs it has. Trial & error means of worms, leeches, etc. & selection of results

Modifiability of Rs & Its Dependence on Physiol. States:

Sea urchin Rs two diff't ways to reach ♂ depending on whether chem. 5 present or not.

Physical states cont.

Flatworms R's influenced by ff'g physiol. state (Pearl): hunger, satiety, sleep, normal activity, heightened activity, excited cond.

Crayfish & crabs learned to choose 1 of 2 openings to water. Yerkes lasted 10 days very well, 14 days. Learned in 1 trial after other side closed. // Also feed beneath a screen.

Analysis w. Discussion of Theories:

Comparison of Uni & Multi cellular:

1) The protozoa R. to all classes of S that higher forms do.
2) The R's of . are not direct physical or chemical result of S themselves but indirect result of forces already present in animal.
3) Structure of organism plays a large part in determining R. There are only certain acts wh. the organism can perform.
4.) Spontaneous action occurs in both prot. & meta zoa.
5) Protozoa have more sensitive spot equiv. to sense organs of meta
6) Conduction occurs in protozoa – Vorticella.
7) Summation of S.
8) Reversal of R. w. △ in degree of same S.
9) Regulatory modifiability of behav. dep. on past history.
10) Physiol. condition of org. determines R.
11) Optimum S. △→ worse + avoid R, △→ better no R.
12) Motif that subjects to varied condit.'s, or varied movt.'s (Jennings) from which selection is made.

No evid. of diff. ce of fundamental character bet. meta & proto.
No imp. additional features w. addition of n. syst.
J. doesn't emphasize importance of n. syst.

Tropisms & the "Local Action theory of tropisms":

The S acts locally on motor organs so they act unsymmetrically till organism orients itself symmetrically. Seen on cilia & ...

Holds fairly well for amoeba + R's, not for + R's.

Obs. of infusoria is completely opposed, S not local. R's depends on der. of movt & internal factors except in R's to elect. current.

Directn. of bacteria dep. on own body axis, not S'g agent.

No indicatn. of such in Hydra. Echinoderms have body axis & orient but locomot. guided by local elements. however = indep. units.

Planaria better

For the lower organisms considered here, the local action theory of tropisms is of little value. It makes use of certain simple phenomena that actually exist, but elevates these into a general explanat. of directed bh'r for wh. they are utterly inadequate.

Other terms employed in accounts of Anim. Bh'r.

Tropisms used in looser sense to show that mov'ts of organisms show defin. relations to the location of external agents. Sometimes tropism restricted inclination of a fixed organism & taxis used for free organisms. Phobisms [illegible] etc

Bh'r of lower organisms composed purely of reflexes? = simple responsive action. vs higher forms

Uexküll thinks so for sea urchin.

Antitype = a reflex performed w/out nervous system. (protozoa)

Sometimes reflexes designated as ① controlled... ② involuntary acts, ③ as reactions always occurring in same manner, J = invariable R'n to a simple S.

Bacteria = nearest to condition. J. does not think P.'s bh'r is uniform enough to be reflex. Still less [illegible], echinoderms, flatworms, sea anemones, & amoeba.

Says amoeba never does the same thing twice.

Can't say reflex is to bh'r as atom is to physics — have to consider variation of physiol. states.

Analysis R'n = Δ of mov't.

Internal Factors: Ext S doesn't cause motion always, often merely Δ's its direction. Persistence in one direct. does not mean persistence of the S. Spontan. activ.s = most important factors in its bh'r.

1) Activity does not require present external S'n. ② Activity may Δ w/out external cause. vorticella, hydra, medusa. ③ Δ's depend on Δs in physiol. states. ④ R's to ext. S depend on physiol. states. ⑤ Physiol state may be Δ'd by progressive internal processes. esp. those of metab. ⑥ P. " " " " action of ext. agents by S. ⑦ Psl. " " by activity of the organism (vortic. contr.) ⑧ Ext agents cause R'n by chang'g the physiol. state of the organism. ⑨ Bh'r depends on physiol. state at the moment. ⑩ P. state Δ in accordance w. certain laws. ⓐ metab processes & ⓑ others ⓐ depends on laws of metabolism, ⓑ on S & activity.

physical state is a dynamic condition tending directly to the production of change.

When a certain physical state has become resolved, thru action of ext. agent or otherwise, into a 2nd state, the resolution becomes easier in the course of time.

The physical states in Stentor to carmine grains.

A → B (carmine) → C (bend) → D (contract)

later A → D or A → B′ → C′ → D

Any learning Rn.

= The law of the resol. of p. st. s. = "The resol. of one phys. state into another becomes easier and more rapid after it has taken place a no. of times." Men assoc. Habit Form. & learning in higher forms, also holds for Stentor & Vorticella. no theoretical reason for supposing it limited to higher animals (synaptic n. syst.)

(11) Diff. Factors on which Bhr depends:

1) Physical state wh. in turn depends on

2) Present ext. S

3) Former " "

4) " Rns

5) Laws of resolut. of phys states into one another.

(B) External Factors

Δ in Environment → Δ in Rn.

Often has to be Δ in certain direction. "away from optimum".

Rns to representative S as to mechan wh. secures food indirectly or to a shadow highly dev. in higher forms

Accounts for these in terms of law of resolut. of physical states.

Question of whether it carries over division of protozoa.

Bhr = fundamentally regulatory.

Action System limits of structure

an organisms repertoire of movts. = a coordinated system.

Discrimination = accuracy w. which the tendency to R is adjusted to the injuriousness of the Sg agent

Positive Rn in infusoria is a secondary result of negative ones.

Actual " "s may be derived from negative thru law of resolut. of phys states. So negative Rns = building stones from wh + Rns built up.

3 most signif. features of B'hr = regulatory

1. determination by relation of internal & external conditions & interference w. these causes a Δ in B'hr.
2. selection from conditions produced by varied or unexpressed motor.
3. readier resolution of physical states after repetition.

spontaneous in sense due to internal energy.
trigger reactions released by " & external stimuli.

Development of B'hr.

based on presumption that law of recent. is generally valid for lower forms & that the effect is lasting enough to result in development (H.)

How can B'hr become more regulatory?

① A weak S comes to cause R in before the strong one actually hits.
② Comes to R to representative S. } (of the 2 events are consistently related.
③ Change from dependence on present S to lasting internal physical processes, past S, etc.
④ Increased variety & precision of R's. (by means of random) anything possible is tried, anything advantageous is kept.
⑤ Congenital variat.s appear in progeny.
⑥ Acquirements of unicellular parents are retained by offspring.

For metazoans "organic selection" holds these improvements must in line w. the general adaptations of the animals were best.

Relatn to Psychic B'hr:

1. need be far as possible objective terms.
Mean diff in that B'hr of man is accompanied by "subjective states" says critic. not open to experiment. in other organ.
Thanks use of objective terms leaves gulf betw. man & lower forms.
Env judged by Ri, also discriminate, places all lower organ. have it as judged by others = 7 of - Rs & diff things.
attention = interference of 1 S w. Rs another. Adams it
subj. states defined by Ri in higher forms - lower than same.
pain = neg. Ri. & pleasure = pleas. Fear = neg Ri to
repres. S. Crustacea & flatworms (& starfish compare fish) memory
Assoc. memory in Crustacea. bell screen & food
Intell. seen in Protozoa
No diffc in kind between B'hr of lower & higher animals.

Chain reflexes = reactions where each successive phase is determined by a preceding one.

Compensatory mvmt.s = reactions to unusual conditions which tends to restore the usual relationships.

Desire = as Hydra when hungry opens mouth widely when immersed in nutritive fluid = physiol. state favoring certain Rins (for J = subjective).

"Trial movements" = Rins occurring under disturbing (objective) conditions that may result in new connections some of which may be less disturbing.

Instinct = definite reaction forms combined into complex trains of action that are inherited.

Intelligence = mastery of Sit in accordance w. experience.

Kinesis = reactions in which orientation is not a feature.

Learning = reaction in a more effective way after experience.

Spontaneous mvmt = activity resulting primarily from physiol. states, internal energy. Subs exter. S.

Law of Δ of physiol. states = readiness of one physiol. state into another becomes easier and more rapid after it has taken place a number of times.

End or purpose = subjective state called an idea in man.

Catastrophic action = mvmt of ions toward cathode. + - charges

Selection from among overproduced mvmt.s

Stat Rins of each, Am., P., bacteria, ciliates, Hydra, planaria, sea anemone, etc. to kind of S:

Work thru general ?s a/1st exam. General summaries etc.

Action System = an animal's repertoire of unitary actions, from the combination of which all its behavior is composed.

Tropism = a relatively fixed reaction to such simple S as gravity, light, temp'tr, contact w. solids, etc. "forced movt"

The tropism theory = local action theory of tropisms. Local action of a S on motor organ produces a definite orientation w. respect to the S.

+ Fixed organisms vs. taxis for free.

+ Parts of organisms show dep. relations to the location of external agents.

Reaction = an observable change of movement.

Adaptive Rx = Rx which tends to preserve the life of an animal and aid it in carrying on its normal activities.

Weber's law = it's the relative change in environment, not the absolute change, that causes a perceptible difference in sensation.

Acclimatization = become accustomed to certain conditions so as to cease reacting to them, tho the conditions remain the same.

Activity = reflex performed w'out a nervous system.

Attention = interference of one S w. the Rx to another.

Choice = acceptance or + Rx to some things vs. rejection or − Rx to others.

Discrimination = different Rx's to diff't S.

Law of dynamogenesis = psy. ideas of movt in man = phys. states.

Organic selection = the action of natural selection on characters plays a part in behavior would be guided by laws similar to or identical with those controlling the progress of the individual.

Amoeba R to - kinds of S.
The amoeba's R in system =
Amoeba to touch S.
Weber's law holds for bacteria? when R is considered rather S.
3 factors on whi. P's spiral course depends.
Avoiding R of P. = 1) reflex structurally det's
2) trial in human sense
3) forced movt.
P's Rs as oriented, unoriented, none, unknown for whole list of S.
The animals that R to light list +, -, indifferent.
R of infus. to galvan. current depends on
Justification of attent'n to Rs to galvanic current.
Bhr of proto's differs from meta's essentially.
Hydra to, amoe. from strongly S'd region
R of stentor to light dep's on freq. direction, intensity, or both?
Reflex bhr depends on n. syst. T or F.
Reflex should be limited to exceeds bhr wh has become autom.
T F = limited or not to man.
Imp. of reflexes accd'g to Jenn's.
Know exactly what a reflex is.
Bhr at a given moment dep's on 5 factors?
In applic. of J's work w lower anims to higher, the essential points are:
How objective is J's descrip of anim. bhr?
+ or - Rs = more primitive
Treatment of consciousness.
Defin. of bhr = ?
Why do some S cause orient of P while others do not.
Differ bet. "tropisms" & "local action theory of tropisms"
Evid. for & vs. choice in bhr of amoeba, stentor, sty lonychia etc.

Elect., Light, Temp., Mech., Chem.

Amoeba:
- Light – neg.
- Elect. – to cathode
- Heat – neg.
- Mech – " undirected
- Chem – "

Paramecia:
- Light – name neg to ultraviolet
- Elect – to cathode
- Temp – opt = 24-28°
- Gravity – up orient
- Water current – orients ant. up stream
- Chem – + dil. H_2S, ++ slight acid
- Mech – neg. + contact

Bacteria:
- Light – most no Ri
- Elect –
- Temp –
- Contact +
- Chem. – + to O_2 many collect in near. kinds of chem's for no good.

Stentor = neg. to light
Euglena = pols " " & up to gravity
Spirogyra = " "

Euglena – no Ri to elect. current.
Flagellates – to anode

All ciliate infusoria { Elect curr water cilia cathode side strike forward and " anode " " backward.

Hydra
- Elect – foot unattached tent → cathode.
  " " " → anode.
- Gravity – in line, head up usually
- Light – part.

Gonionemus = complex & light

[Go thru particular cases of bhr, Stentor, etc. & Review the notes so far taken.]