**Insect Virus Compilations**

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# THE NUCLEIC ACIDS OF SOME INSECT VIRUSES*

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With the application of recent analytical methods it has become established that nucleic acids from various sources differ in their contents of the purine and pyrimidine bases. These quantitative variations presumably represent one of the bases of biological specificity in these substances.

Analyses of desoxyribonucleic acids (DNA's) from a number of animal, plant, and microbial sources have led to the conclusion that DNA composition is a species character (Chargaff, 1950, 1951; Wyatt, 1951b, 1952). While the DNA's of higher animals are quite similar in composition, those of bacteria and viruses exhibit more extreme variations (Chargaff, Zamenhof, Brawerman, and Kerin, 1950; Smith & Wyatt, 1951); among most or all, however, certain regularities in the nucleotide ratios are evident (Chargaff, 1951; Wyatt, 1952). Among plant viruses, which contain ribonucleic acid (RNA), small differences in purine-pyrimidine ratios have been shown among strains of tobacco mosaic, and these differ more markedly from other

unrelated plant viruses (Markham and Smith, 1950, 1951). It thus seemed that nucleic acid analysis would aid in characterization of the viruses found in insects, being studied in this laboratory, and possibly provide a criterion of relationship among them.

The insect viruses comprise a numerous, highly adapted, rather host-specific group (Bergold, 1947, 1948a, 1950a, 1950b; Steinhaus, 1949a, 1949b; Steinhaus, Hughes and Wasser, 1949; Smith and Wyckoff, 1951). General methods for their isolation and purification have been worked out, and their morphology extensively studied, by Bergold (1947, 1948b, 1950a). On morphological and biological grounds, they appear to form a fairly homogenous group, which may be subdivided, however, into (a) polyhedral viruses (genus Borrelina Paillot; see Steinhaus, 1949a), occurring in numbers in polyhedral inclusion bodies, and (b) capsule or granule viruses (genus Bergoldia Steinhaus), occurring singly in minute oval inclusions.

The manner of their occurrence in inclusion bodies makes it possible to prepare these viruses virtually free of host material and of cross-reaction with host antigens (Bergold & Friedrich-Freksa, 1947), a situation almost unique among animal viruses. They are relatively simple in chemical composition, having, in addition to protein, about 15% of DNA (Bergold & Pister, 1948b; Smith & Wyatt, 1951), and extremely little lipid

or non-nucleic acid carbohydrate (Wyatt, 1950). They thus provide exceptionally favorable material for comparative studies of nucleic acid composition in related micro-organisms.

Analyses are now described of the nucleic acids of eleven species or strains of insect viruses. The results are examined for their value in characterizing the viruses, and for what light they may throw on the problems of nucleic acid composition. An analysis of the nucleic acids of one of these viruses (Smith & Wyatt, 1951), and initial results from this comparative study (Wyatt, 1952) have already been reported.

## EXPERIMENTAL

### Preparation of the viruses

The viruses for analysis were isolated from purified polyhedral bodies or capsules by the procedure of Bergold (1947, 1950a). The inclusion bodies which provided the starting material were obtained from the cadavers of diseased insects, and purified by sedimentation and repeated washing with water until the residue was almost white and showed very few foreign particles under the microscope.

The standard procedure for the isolation of the viruses is as follows, details being varied only slightly to suit

the properties of the different viruses. Dry, purified polyhedra or capsules are suspended at a concentration of 5 mgm./ml. in a solution containing NaCl (or KCl) 0.05 M. and $Na_2CO_3$ (or $K_2CO_3$) 0.006 to 0.03 M.[1]

[1] The strength of alkali is adjusted to the solubility of the inclusion bodies of each species, as follows: Polyhedra from B. mori and C. p. eurytheme, 0.006 M.; from P. dispar, L. monacha and N. sertifer, 0.008 M.; from C. fumiferana, P. seriata, M. americanum and M. disstria, 0.03 M.; capsules from C. fumiferana and C. murinana, 0.03 M.

After 2 to 3 hours, with occasional shaking, dissolution of the inclusion body protein and liberation of the virus is complete; this can be followed with the dark-field microscope. The suspension is then centrifuged at 4000-6000 r.p.m. (Sorvall SS1 centrifuge; 1600-3600 g) for 5 minutes to remove undissolved remnants and impurities; some further virus can be recovered by suspending this residue in water and re-centrifuging. The virus is then sedimented at 11,000 r.p.m. (12,000 g) for 45 minutes and the clear supernatant liquid containing dissolved capsule or polyhedral protein is set aside. The virus is suspended in distilled water or $10^{-4}$ M. $Na_2CO_3$ of volume equal to the

see 4th line
below last sentence
as .0001 M

original solution, and again sedimented at 11,000 r.p.m. for 45 minutes. With some species, a brown layer consisting mainly of virus membranes (Bergold, 1952) and the undissolved surface skins of the polyhedra lies on top of the bluish-white sediment of virus; this can often be removed by rinsing with a drop of water. The remaining sediment consists almost wholely of virus; a number of the preparations used for nucleic acid analysis have been examined in the electron microscope by Dr. G. H. Bergold.

For hydrolysis, the virus is centrifuged down from a small volume of water in a 6 x 50 mm. glass culture tube, and dried. The yield is generally 2.5 - 3.5 per cent of the inclusion bodies. 60-100 mgm. of polyhedra or capsules, giving 1.5-3.5 mgm. of virus, were used for each analysis.

## Hydrolysis

Perchloric acid (70 per cent, Marshak and Vogel, 1951) was used for hydrolysis, since it liberates the purine and pyrimidine bases from whole virus, along with protein degradation products which interfere little with estimation of the bases. Hydrolysis is carried out in sealed tubes in a thermostatically controlled bath. After heating,

the hydrolysate is diluted with water, and the black carbon residue is brought into suspension by grinding with a glass rod, since it tends to adsorb P. Aliquots are taken with micro-pipettes[2] for chromatography, P estimation, and, if desired, N estimation.

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[2] Self-adjusting capillary type, made in the laboratory or purchased from Microchemical Specialties Ltd., Berkeley, California.

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In order to obtain satisfactory emptying of the pipettes, the samples for inorganic analysis are dispensed onto small pieces of filter paper, which are dropped into flasks for incineration.

Since early experiments showed variability in the yield of thymine, some tests were carried out with purified ox spleen DNA to determine the optimal conditions. Temperatures above 100° were found to cause loss of thymine (about 15% in 1 hour at 110°). The amount of $HClO_4$ used is also important: with 8-15 µl. of 70% $HClO_4$ per mgm. DNA, constant yields are obtained, but with greater amounts of reagent, some thymine is lost (about 2.5% with 20 µl./mgm., and 10% with 30 µl./mgm.). When a mixture of DNA (15%) with protein (bovine plasma albumen, 85%) was subjected to hydrolysis,

the amount of $HClO_4$ used was less critical, and yields were unchanged over the range 10-30 µl. $HClO_4$/mgm. DNA. Evidently, $HClO_4$ has a destructive action on thymine which can be overcome by the buffering effect of either protein or sufficient nucleic acid.

From these results it seems likely that even under optimal conditions with $HClO_4$ a small amount of thymine is lost. This would partially account for the discrepancy from the yields obtained with formic acid (Wyatt, 1951b). The method chosen, however, gave very consistent results, satisfactory for the comparison of biological materials.

The yields of bases from ox spleen DNA, with and without added protein, and the percentages of total P and N accounted for by the estimated nucleotides, are given in Table I. The change in apparent yields resulting from the presence of protein nowhere exceeds 3 per cent.

The working procedure adopted was finally as follows. To the dry virus is added 3-4 µl. 70% $HClO_4$ per mgm. weight, and the tube is closed and heated to 100° for 2 hours. Sufficient water is added to make the volume of hydrolysate about 25 µl., and the hydrolysis residue is ground into suspension. This allows two 8-µl. portions for chromatography and two or three 2-µl. portions for P estimation.

## Estimation of the Bases

Published prodedures (Markham and Smith, 1949, 1951; Wyatt, 1951b), using paper chromatography, were followed with only minor refinements in order to obtain reliable results from the least possible material. Aqueous isopropanol (65 per cent) containing HCl (2.0 N.) was used exclusively as the chromatographic solvent. Each spot was eluted in 4 ml. of 0.1 N-HCl, by standing overnight, with mechanical shaking before and after standing. It was found that by sufficient cleanliness and care with the blanks, reliable results (difference between replicates rarely exceeding 3%) could be obtained with optical densities as low as 0.1, corresponding to about 5 µgm. of purine or pyrimidine.

## Inorganic Analyses

Phosphorus (usually 1.5-4 µgm. per sample) is estimated by the nephelometric method of Bergold and Pister (1948a), and nitrogen by a micro-Kjeldahl procedure.

## RESULTS ~~Results~~

All of the viruses gave rise only to the purines adenine and guanine and the pyrimidines cytosine and thymine. Neither 5-methyl-cytosine nor uracil could be detected. Some

chromatograms showed a faint spot near the position of uracil; this, however, did not have the characteristic absorption spectrum of uracil and was found to be associated with the brown "membrane" portion of a virus preparation. The cleanest white preparations gave no spot in this position, confirming the virtual or entire absence of RNA from these viruses (Bergold & Pister, 1948b; Smith & Wyatt, 1951). In one preparation of C. p. eurytheme virus, the maximum possible uracil, indicated by the absorption of an eluate from the uracil position, was equivalent to 3% of the thymine present; as this included the absorption of protein degradation products, any actual uracil must have been considerably less. The amount of DNA estimated by summing the bases corresponds to 10-15% of the various viruses, but these figures are only approximate since the prodedure was not designed to refer results to dry weight.

The proportions of the several bases in the 11 viruses examined are listed in Table II. The ~~portion~~ fraction of total P accounted for by the estimated nucleotides averages 88%. When compared with the corresponding figure of 100% for ox DNA analysed in the presence of protein by the same procedure, this suggests that some 10% of the virus P may occur

in compounds other than nucleotides.

The mean ratios of the bases from Porthetria dispar virus are in good agreement with those previously reported for the isolated nucleic acid of this virus (Smith & Wyatt, 1951).

The viruses are arranged in the table in order of increasing content of adenine. It will be noted that the thymine content of the different nucleic acids then also form an ascending series, while the values for both guanine and cytosine are arranged in descending order. The ratios of adenine to thymine, and guanine to cytosine, are nearly constant for all, while the ratio of adenine plus thymine to guanine plus cytosine (AT/GC ratio) gives an index of the position of a virus in the series. These regularities are brought out in Table III. The variation in adenine/thymine and guanine/cytosine ratios within this group of organisms falls within experimental error. The corresponding ratios for ox spleen DNA are also ~~very~~ similar. These constant ratios are in accord with the regularities in the composition of DNA's which were first pointed out by Chargaff (1951) and have already been confirmed and discussed (Wyatt, 1952).

An incidental result of this balanced variation in nucleotide composition is that the mean nucleotide residue

weight in each nucleic acid (i.e. the mean molecular weight of the nucleotides less 18 for water eliminated in linkage) is also constant. This figure does not fall outside the range 308.8 - 309.3 for the entire series, although the molecular weights of the nucleotides vary widely (desoxyadenylic acid 331, desoxyguanylic 347, desoxytidylic 307, thymidylic 322).

## DISCUSSION ~~Discussion~~

Because of their possessing surface membranes and a variety of morphological forms indicative of a life cycle, these viruses have been described as organisms (Bergold, 1950a). The term seems appropriate, and is used in this paper. Yet their possessing only one type of nucleic acid is a characteristic of fundamental importance, shared with bacteriophages (Cohen and Arbogast, 1950), which differentiates them sharply from bacteria and other microorganisms with which they might be compared. Whether rickettsiae contain RNA seems not to be definitely settled (Cohen, 1950). Lack of RNA in certain viruses may be associated with their parasitic metabolism, which frees them from the need to synthesize enzyme systems. The remaining DNA has presumably genetic value.

According to the composition of their DNA, the eleven viruses analysed have been arranged in a series with the proportions of the bases changing in a balanced manner. Their distribution in the scale, however, is not random, but shows grouping into sets with very similiar or identical composition. This is most clearly shown by the AT/GC ratios in Table III, which have values of approximately 0.95 for two viruses, 1.35 for four viruses, and 1.67 for two. None of the differences in content of individual bases within the group having AT/GC ratio 1.35 (M. americanum, M. disstria, B. mori, C. p. eurytheme) are significant when examined by the t test. This outcome was scarcely expected in view of the results with animal DNA's (Wyatt, 1951a), which suggested a unique, if only slightly different, composition for each species, and those with tobacco mosaic (Markham & Smith, 1950) which indicated that even related virus strains could differ in nucleic acid composition.

There is some evidence in the results that related viruses tend to have similarly constituted nucleic acid. Thus, the two capsule viruses are close together in the scale, so are the two pairs of polyhedral viruses whose hosts are members of the same family. Such well-adopted,

host-specific parasites may be expected to have evolved along with, and to some extent to parallel the phylogenetic relationships of their hosts. No connection was obvious, however, between the morphological characteristics of the viruses (Bergold, 1952) and their nucleic acids. Their serological relations remain to be investigated.

Similarity of nucleic acid composition, on the other hand, obviously does not necessarily imply close relationship of the viruses. For example, the polyhedral virus of the sawfly N. sertifer and the capsule virus of the tortrix C. murinana are biologically as different as any pair in the series, yet have apparently identically composed DNA. The group with AT/GC ratio approximately 1.35 also includes quite unrelated species. Yet the virtual identity of nucleic acid composition of so many species must have some significance. DNA composition in these viruses appears to change by discrete steps; yet the magnitudes of these steps are not quite sufficiently uniform to represent changes by equal numbers of nucleotides. In attempting any such explanation, it would be important to establish by further analyses whether intermediates occur. Moreover, the steps do not appear to represent mutations, since distinct viruses can have the

same DNA composition. Interpretation of these results must probably await better knowledge of the molecular structure of nucleic acids.

The independence of host and virus nucleic acids, already established for bacteriophages (Smith and Wyatt, 1951) is confirmed by the analysis of a polyhedral virus and a capsule virus from the same insect species, C. fumiferana. These have quite distinct nucleic acids. It would be interesting to compare the DNA's of the various host insects. Several attempts to prepare DNA from caterpillars led to only very small and impure yields. Approximate analyses, however, of DNA from B. mori and L. monacha showed that they, like other animals, have a marked excess of adenine and thymine over guanine and cytosine, and that of L. monacha, at least, is quite different from its virus.

While some distinct viruses have the same nucleic acid composition, these analyses can nevertheless take their place among useful taxonomic characters. For example, in a case of apparent cross-infection of L. dispar with B. mori virus, such as was obtained by Bergold (1943), analysis of virus DNA would establish whether this represented true infection or provocation

of latent virus. The sensitivity of the method is adequate for such tests, as approximate ratios can be obtained from less than 1 mgm. of virus.

## SUMMARY

Eleven viruses causing polyhedral diseases or capsule diseases of insects have been isolated and ~~subjected to~~ analysed quantitatively ~~analysis~~ for the purines and pyrimidines of their nucleic acids. The viruses possess approximately 10-15% of DNA. No RNA was detected. The DNA's contain adenine, guanine, cytosine, and thymine, but no methylcytosine. The proportions of the purines and pyrimidines vary in the different species in a balanced way so that adenine/thymine and guanine/cytosine are constant ratios close to unity, but the ratio adenine + thymine/guanine + cytosine gives a characteristic index ranging from 0.71 to 1.87, by which the viruses may be arranged in a scale. Viruses possessing characteristics in common tend to fall near one another on the scale, but proximity on the scale does not necessarily imply relationship. The scale is not a continuous distribution, but contains groups of viruses having identical DNA composition, with intervals between. The

one group comprises 1 poly + 1 cap

fundamental significance of these results remains uncertain at present, but it is clear that nucleic acid composition can be a useful taxonomic character for viruses.

Space >

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Table I

Yield of bases from ox spleen DNA

after hydrolysis in $HClO_4$ (70%, 15 µl./mgm. NA) at 100°

| Material analysed | Hydrolysis time | Moles per 100 moles total bases* | | | | P accounted for, per cent | N accounted for, per cent |
|---|---|---|---|---|---|---|---|
| | | Adenine | Thymine | Guanine | Cytosine | | |
| Purified DNA | 1 hr. | 28.2 | 26.3 | 23.0 | 20.7 | 95 | 97 |
| " | 2 hr. | 28.5 | 26.0 | 23.2 | 20.7 | 98 | 97 |
| DNA 15%, albumen 85% | 1 hr. | 27.8 | 27.0 | 22.7 | 20.7 | 99 | - |
| " | 2 hr. | 27.8 | 26.9 | 22.7 | 20.9 | 100 | - |

* Allowing 1.3 for methylcytosine, not estimated in these experiments.

Table II

Purine and pyrimidine composition of DNA's of insect viruses

| Inclusion body type | | Host species | Host order and family | No. of analyses | Moles per 100 moles total bases | | | | P accounted for, per cent |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Adenine | Thymine | Guanine | Cytosine | |
| Polyhedra | | Porthetria dispar (L.), Gypsy moth | Lepidoptera Lymantriidae | 4 | 21.2 ± 0.15 | 20.05 ± 0.18 | 30.5 ± 0.11 | 28.25 ± 0.09 | 92 |
| | | Lymantria monacha L., Nun moth | " | 1 | 24.6 | 23.8 | 26.8 | 24.7 | - |
| | | Choristoneura fumiferana (Clem.), Spruce budworm | Tortricidae | 3 | 24.8 ± 0.12 | 24.0 ± 0.09 | 26.7 ± 0.14 | 24.5 ± 0.14 | 86 |
| | | Ptychopoda seriata Schrk., | Geometridae | 2 | 26.7 | 25.7 | 24.4 | 23.2 | 87 |
| | | Malacosoma americanum (F.), Eastern tent caterpillar | Lasiocampidae | 3 | 29.2 ± 0.22 | 28.0 ± 0.34 | 22.5 ± 0.19 | 20.2 ± 0.11 | 93 |
| | | Malacosoma disstria Hbn., Forest tent caterpillar | " | 3 | 29.2 ± 0.23 | 28.5 ± 0.37 | 21.9 ± 0.19 | 20.3 ± 0.07 | 86 |
| | | Bombyx mori L., silkworm | Bombycidae | 3 | 29.3 ± 0.25 | 28.0 ± 0.33 | 22.5 ± 0.05 | 20.2 ± 0.13 | 88 |
| | | Colias philodice eurytheme Bdvl., alfalfa butterfly | Pieridae | 4 | 29.9 ± 0.35 | 27.6 ± 0.08 | 22.4 ± 0.15 | 20.1 ± 0.22 | 90 |
| | | Neodiprion sertifer (Geoffr.), Pine sawfly | Hymenoptera Tenthredinidae | 2 | 32.3 | 30.3 | 19.5 | 17.9 | - |
| Capsules | | Cacoecia murinana Hb. | ~~Lepidoptera~~ Tentredinidae * | 3 | 32.1 ± 0.14 | 30.5 ± 0.44 | 19.7 ± 0.35 | 17.8 ± 0.29 | 84 |
| | | Choristoneura fumiferana (Clem.), Spruce budworm | " | 1 | 32.8 | 32.4 | 18.4 | 16.4 | - |

Independent analyses performed on different preparations of virus.

Mean value and its standard error.

* = Tortricidae

Table III

Molar proportions of the bases in DNA's of insect viruses

| Inclusion body type | | Virus host | Adenine / Thymine | Guanine / Cytosine | Purines / Pyrimidines | Adenine + Thymine / Guanine + Cytosine | |
|---|---|---|---|---|---|---|---|
| Polyhedra | | P. dispar | 1.06 | 1.08 | 1.07 | 0.71 | 364 |
| | | L. monacha | 1.03 | 1.08 | 1.06 | 0.94 | 350 |
| | | C. fumiferana | 1.03 | 1.09 | 1.06 | 0.95 | 260 |
| | | P. seriata | 1.04 | 1.05 | 1.04 | 1.10 | 299 |
| | | N. americanum | 1.04 | 1.11 | 1.07 | 1.34 | 315 |
| | | N. disstria | 1.02 | 1.08 | 1.05 | 1.36 | 324 |
| | | B. mori | 1.04 | 1.11 | 1.07 | 1.34 | 278 |
| | | C. p. eurytheme | 1.08 | 1.11 | 1.09 | 1.35 | 277 |
| | | N. sertifer | 1.07 | 1.09 | 1.07 | 1.67 | - |
| Capsules | | P. murinana | 1.05 | 1.11 | 1.07 | 1.67 | 256 |
| | | C. fumiferana | 1.01 | 1.12 | 1.05 | 1.87 | 271 |
| | | Ox spleen DNA* | 1.04 | 1.02 | 1.03 | 1.22 | |

* Included for comparison; ratios are taken from the analysis of DNA in the presence of protein, and methylcytosine has been added to cytosine.

Recovery of bases from beef spleen DNA
after hydrolysis in $HClO_4$ at 100°.
Mean values from 3 experiments.

| | Hydrolysis Time | Molar ratios of the bases (total = 4.00) A | T | G | C | P recovery | N recovery |
|---|---|---|---|---|---|---|---|
| DNA | 1 hr | 1.135 | 1.057 | 0.925 | 0.832 | 94.9 | 97.0 |
| DNA | 2 hrs | 1.144 | 1.046 | 0.931 | 0.830 | 98.4 | 96.6 |
| DNA + protein | 1 hr | 1.119 | 1.086 | 0.913 | 0.831 | 98.6 | - |
| DNA + protein | 2 hrs. | 1.120 | 1.081 | 0.911 | 0.839 | 100.4 | - |

# Ratios in Inner Virus NA's.

re-calculated 29-xi-51.

| | | A | | | G | | | C | | | T | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pd | 12-ii | 21.2 | 0 | 0 | 30.6 | 1 | 1 | 28.1 | 1.5 | 2.25 | 20.2 | 1.5 | 2.25 |
| | 24-iv | 20.8 | 4 | 16 | 30.4 | 1 | 1 | 28.5 | 2.5 | 6.25 | 20.2 | 1.5 | 2.25 |
| | 19-vi | 21.5 | 3 | 9 | 30.7 | 2 | 4 | 28.2 | 0.5 | 0.25 | 19.5 | 5.5 | 30.25 |
| | 15-xi | 21.3 | 1 | 1 | 30.2 | 3 | 9 | 28.2 | 0.5 | 0.25 | 20.3 | 2.5 | 6.25 |
| | 4 | 84.8 | | 12)26 | 121.9 | | 12)15 | 153.0 | | 12)9 | 80.2 | | 12)41 |
| | | 21.2 | | 2.2 | 30.5 | | 1.25 | 28.25 | | 0.75 | 20.05 | | 3.4 |
| | | | | $\sqrt{}$ = 1.5 | | | $\sqrt{}$ = 1.1 | | | $\sqrt{}$ = 0.9 | | | $\sqrt{}$ = 1.8 |
| Bm. | 5c | 29.3 ± 0.25 | | | 22.5 ± 0.05 | | | 20.2 ± 0.13 | | | 28.0 ± 0.33 | | |
| Cpe | 2-iv | 29.2 | 7 | 49 | 22.7 | 3 | 9 | 20.6 | 5 | 25 | 27.4 | 2 | 4 |
| | 2-vi | 29.4 | 5 | 25 | 22.5 | 1 | 1 | 20.3 | 2 | 4 | 27.7 | 1 | 1 |
| | 3-viii | 30.3 | 4 | 16 | 22.1 | 3 | 9 | 19.9 | 2 | 4 | 27.7 | 1 | 1 |
| | 4-x | 30.6 | 7 | 49 | 22.1 | 3 | 9 | 19.6 | 5 | 25 | 27.7 | 1 | 1 |
| | | 4)119.5 | | 12)139 | 89.4 | | 12)28 | 80.4 | | 12)58 | | | 12)7 |
| | | 29.9 | | 12 | 22.35 | | 2.3 | 20.1 | | 4.9 | 27.6 | | 0.6 |
| | | | | $\sqrt{}$ = 3.5 | | | $\sqrt{}$ = 1.5 | | | $\sqrt{}$ = 2.2 | | | $\sqrt{}$ = 0.8 |
| Mg | 11-viii | 29.5 | 3 | 9 | 22.7 | 2 | 4 | 20.0 | 2 | 4 | 27.6 | 4 | 16 |
| | 28-ix | 28.8 | 4 | 16 | 22.1 | 4 | 16 | 20.4 | 2 | 4 | 28.7 | 7 | 49 |
| | 14-xi | 29.4 | 2 | 4 | 22.6 | 1 | 1 | 20.2 | 0 | 0 | 27.8 | 2 | 4 |
| | | 87.7 | | 6)29 | | | 6)21 | | | 6)8 | 84.1 | | 6)69 |
| | | 29.2 | | 5 | 22.5 | | 3.5 | 20.2 | | 1.3 | 28.0 | | 11.5 |
| | | | | $\sqrt{}$ = 2.2 | | | $\sqrt{}$ = 1.9 | | | $\sqrt{}$ = 1.1 | | | $\sqrt{}$ = 3.4 |
| Md | 13-xi | 29.7 | 5 | 25 | 22.3 | 4 | 16 | 20.2 | 1 | 1 | 27.8 | 7 | 49 |
| | 14-xi | 29.0 | 2 | 4 | 21.8 | 1 | 1 | 20.2 | 1 | 1 | 29.0 | 5 | 25 |
| | 15-xi | 29.0 | 2 | 4 | 21.7 | 2 | 4 | 20.4 | 1 | 1 | 28.8 | 3 | 9 |
| | | | | 6)33 | | | 6)21 | | | 6)3 | 85.6 | | 6)83 |
| | | 29.2 | | 5.5 | 21.9 | | 3.5 | 20.3 | | 0.5 | 28.5 | | 14 |
| | | | | $\sqrt{}$ = 2.3 | | | $\sqrt{}$ = 1.9 | | | $\sqrt{}$ = 0.7 | | | $\sqrt{}$ = 3.7 |

| | | A | | | G | | | C | | | T | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lm | 18-xi | 24.6 | | | 26.8 | | | 24.7 | | | 23.8 | | |
| PCf | 20-xi | 24.6 | 2 | 4 | 26.8 | 2 | 4 | 24.4 | 1 | 1 | 24.2 | 2 | 4 |
| | 26-xi | 25.0 | 2 | 4 | 26.7 | 0 | 0 | 24.4 | 1 | 1 | 24.0 | 0 | 0 |
| | 30-xi | 24.9 | 1 | 1 | 26.4 | 3 | 9 | 24.8 | 3 | 9 | 23.9 | 1 | 1 |
| | | 24.8 | | 6\|9 1.5 | 26.7 | | 6\|13 2.1 | 24.5 | | 6\|11 1.8 | 24.0 | | 6\|5 0.85 |
| | | | | √=1.2 | | | √=1.4 | | | √=1.4 | | | √=0.9 |
| Ps | 26-xi | 26.7 | | | 24.3 | | | 23.2 | | | 25.7 | | |
| | 30-xi | 26.6 | | | 24.5 | | | 23.2 | | | 25.7 | | |
| | | 26.7 | | | 24.4 | | | 23.2 | | | 25.7 | | |
| CCm | 1-iii | 32.0 | 1 | 1 | 20.2 | 5 | 25 | 18.3 | 5 | 25 | 29.8 | 7 | 49 |
| | 13-iv | 32.0 | 1 | 1 | 19.8 | 1 | 1 | 17.8 | 0 | 0 | 30.4 | 1 | 1 |
| | 20-iv | 32.4 | 3 | 9 | 19.0 | 7 | 49 | 17.3 | 5 | 25 | 31.3 | 8 | 64 |
| | | | | 6\|11 | | | 6\|175 | | | 6\|50 | 3191.5 | | 6\|114 |
| | | 32.1 | | 1.9 | 19.7 | | 12.5 | 17.8 | | 8.3 | 30.5 | | 19 |
| | | | | √=1.4 | | | √=3.5 | | | √=2.9 | | | √=4.4 |
| Ns | 20-v | 31.8 | | | 18.6 | | | 18.4 | | | 31.2 | | |
| | 19-vi | 32.8 | | | 20.5 | | | 17.4 | | | 29.3 | | |
| | | 32.3 | | | 19.5 | | | 17.9 | | | 30.3 | | |
| CCf | 20-x | 32.8 | | | 18.4 | | | 16.4 | | | 32.4 | | |

# Summary of Virus Analyses for HA content.

| Species | Date | Wt. polyhedra mg | Wt. virus mg | % yield | Volume ↑ µl | Wt. virus in aliquot mg | Wt HA in aliquot mg. (mean mwt. = 310) | % HA |
|---|---|---|---|---|---|---|---|---|
| Pd | 12-ii | 100 | ? | | | | | |
| | 24-iv | 105 | 3.1 | 2.95 | 16 (16.3) | 1.10 | 0.153 | 13.9 |
| | 19-vi | 80 | 1.8 | 2.25 | 14.2 (15.6) | 1.35 | 0.240 | 17.5 |
| | 15-xi | 60 | 1.2 | 2.0 | 25 (25.9) | 0.38 | 0.55 | 14.5 |
| | | | | 2.40 | | | | |
| Bm | 11-iv | - | 2.0 | - | 16 (17.5) | 0.74 | 0.070 | 9.5 |
| | 2-vi | 100 | 3.5 | 3.5 | 28.6 (31.2) | 1.33 | 0.110 | 8.4 |
| | 3-viii | 100 | 3.8 | 3.8 | 25 (27.8) | 1.14 | 0.085 | 7.5 |
| | | | | 3.7 | | | | |
| Cpc | 2-iv | 100 | 2.6 | 2.6 | 16 (17.9) | 0.95 | 0.104 | 11.0 |
| | 2-vi | 100 | 3.2 | 3.2 | 28.6 (31.0) | 1.23 | 0.147 | 11.9 |
| | 3-viii | 100 | 4.3 | 4.3 | 25 (28.2) | 1.27 | 0.121 | 9.5 |
| | 4-x | 200 | 5.9 | 2.95 | 50 (54.3) | 1.80 | 0.190 | 10.5 |
| | | | | 3.26 | | | | |
| Cm | 13-iv | 174 | 4.8 | 2.8 | 28 (31.5) | 1.06 | 0.183 | 17.2 |
| | 20-iv | 109 | 3.0 | 2.8 | 16 (18.1) | 1.38 | 0.133 | 9.7 |
| | | | | 2.8 | | | | |
| Ns | 20-v | 80 | 1.9 | 2.4 | 16 (17.4) | 0.84 | 0.063 | 7.6 |
| | 19-vi | 80 | 1.4 | 1.4 | 14.2 (15.0) | 0.88 | 0.089 | 10.2 |
| | | | | 1.9 | | | | |

| Species | Date | Wt. fed fish mg. | Wt. virus mg. | Yield % | Volume ↑ µl | Wt. virus in sp. mg. | Wt. NA in sp. mg. | % NA. |
|---|---|---|---|---|---|---|---|---|
| Ma | 11-VIII | 100 | 3.6 | 3.6 | 25 (27.6) | 1.08 | 0.124 | 11.5 |
| | 28-ix | 80 | 3.6 | 4.5 | 25 (27.6) | 1.08 | 0.136 | 12.4 |
| | 14-xi | 60 | 1.8 | 3.0 | 26 (27.3) | 0.55 | 0.65 | 11.8 |
| | | | | 3.7 | | | | |
| Md | 13-xi | 60 | 1.6 | 2.7 | 31 (32.2) | 0.41 | 0.041 | 10.0 |
| | 14-xi | 60 | 1.4 | 2.4 | 26 (27.0) | 0.43 | 0.059 | 13.7 |
| | 15-xi | 80 | 1.8 | 2.25 | 26 (27.3) | 0.55 | 0.065 | 11.8 |
| | | | | 2.44 | | | | |
| Lm | 18-xi | 25 | 0.7 | 2.8 | 8 (8.6) | 0.61 | 0.069 | 11.3 |
| PCf | 20xi | 60 | 1.4 | 2.3 | 25 (26.0) | 0.45 | 0.041 | 9.0 |
| | 26-xi | 80 | 1.5 | 1.9 | 26 (27.1) | 0.46 | 0.059 | 12.8 |
| CCf | 20-xi | 75 | 2.4 | 3.5 | 26 (27.8) | 0.72 | 0.072 | 10.0 |
| $P_3$ | 26-xi | 80 | 1.9 | 2.4 | 26 (27.4) | 0.58 | 0.072 | 12.3 |

Table I

Yield of bases from ox spleen DNA
after hydrolysis in $HClO_4$ (70%, 15 µl./mg. NA) at 100°

| Material analysed | Hydrolysis time | Moles per 100 moles total bases* | | | | P accounted for per cent | N accounted for per cent |
|---|---|---|---|---|---|---|---|
| | | Adenine | Thymine | Guanine | Cytosine | | |
| Purified DNA | 1 hr. | 28.2 | 26.3 | 23.0 | 20.7 | 95 | 97 |
| ~~Purified DNA~~ " | 2 hr. | 28.5 | 26.0 | 23.2 | 20.7 | 98 | 97 |
| DNA 15% albumen 85% | 1 hr. | 27.8 | 27.0 | 22.7 | 20.7 | 99 | - |
| " | 2 hr. | 27.8 | 26.9 | 22.7 | 20.9 | 100 | - |

*Allowing 1·3 for methylcytosine, not estimated in these experiments.

Table III

Molar proportions of the bases in DNA's of insect viruses.

| Inclusion bodies | Virus host | Adenine / Thymine | Guanine / Cytosine | Purines / Pyrimidines | Adenine + Thymine / Guanine + Cytosine |
|---|---|---|---|---|---|
| Polyhedra | P. dispar | 1.06 | 1.08 | 1.07 | 0.71 |
| | L. monacha | 1.03 | 1.08 | 1.06 | 0.94 |
| | C. fumiferana (~~Polyhedra~~) | 1.03 | 1.09 | 1.06 | 0.95 |
| | P. seriata | 1.04 | 1.05 | 1.04 | 1.10 |
| | Ad. americanum | 1.04 | 1.11 | 1.07 | 1.34 |
| | Ad. distorta | 1.02 | 1.08 | 1.05 | 1.36 |
| | B. mori | 1.04 | 1.11 | 1.07 | 1.34 |
| | C. f. erythrene | 1.08 | 1.11 | 1.09 | 1.35 |
| | M. sertifer | 1.07 | 1.09 | 1.07 | 1.67 |
| Capsules | C. murinana | 1.05 | 1.11 | 1.07 | 1.67 |
| | C. fumiferana | 1.01 | 1.12 | 1.05 | 1.87 |
| | Ox spleen DNA* | 1.04 | 1.02 | 1.03 | 1.22 |

* Included for comparison; methylcytosine has been added to cytosine.

Composition of beef spleen DNA as determined after two methods of hydrolysis.

Molar ratios calculated to total 3.95, making 4.00 when 0.05 is added for 5-methyl cytosine.

| | HCOOH (Mean of 11 analyses) | $HClO_4$ (Mean of 9 analyses) |
|---|---|---|
| A | 1.130 ± 0.008 | 1.141 ± 0.013 |
| T | 1.115 ± 0.006 | 1.042 ± 0.018 |
| G | 0.854 ± 0.007 | 0.922 ± 0.009 |
| C | 0.851 ± 0.009 | 0.844 ± 0.004 |

| ·Pd | | A | | | G | | | C | | | T | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12-ii | ·849 | 2 | 4 | 1.222 | 1 | 1 | 1.123 | 8 | 64 | ·806 | 7 | 49 |
| | 24-iv | ·831 | 16 | 256 | 1·218 | 5 | 25 | 1.140 | 9 | 81 | ·809 | 10 | 100 |
| | 19-vi | ·861 | 14 | 196 | 1·228 | 5 | 25 | 1.130 | 1 | 1 | ·782 | 17 | 289 |
| | | 3)2.541 | | 6)456 | 3)3.668 | | 6)51 | 3)3.393 | | 6)146 | 3)2.397 | | 6)438 |
| | | 0.947 | | 76 | 1.223 | | 8 | 1.131 | | 24 | 0.799 | | 73 |
| | | ±0.009 | | | ±0.003 | | | ±·006 | | | ±·009 | | |
| Bm | 11-iv | 1.174 | 3 | 9 | 0.899 | 0 | 0 | 0.806 | 2 | 4 | 1.118 | 4 | 16 |
| | 2-vi | 1.152 | 19 | 361 | 0.903 | 4 | 16 | 0.800 | 8 | 64 | 1.146 | 24 | 576 |
| | 3-viii | 1.186 | 15 | 225 | 0.896 | 3 | 9 | 0.817 | 9 | 81 | 1.101 | 21 | 441 |
| | | 3)3.512 | | 6)595 | 3)2.698 | | 6)25 | 3)2423 | | 6)149 | 3)3.365 | | 6)1033 |
| | | 1.171 | | 99 | 0.899 | | 4 | ·808 | | 25 | 1.122 | | 172 |
| | | ±·010 | | | ±·002 | | | ±·006 | | | ±·013 | | |
| Cpe | 2-iv | 1.170 | 15 | 225 | 0.909 | 11 | 121 | 0.824 | 13 | 169 | 1.099 | 6 | 36 |
| | 2-vi | 1.175 | 10 | 100 | 0.901 | 3 | 9 | 0.813 | 2 | 4 | 1.160 | 5 | 25 |
| | 3-viii | 1.211 | 26 | 676 | 0.883 | 15 | 225 | 0.797 | 14 | 196 | 1.107 | 2 | 4 |
| | | 3)3.556 | | 6)1001 | 3)2.693 | | 6)355 | 3)2.434 | | 6)369 | 3)3.316 | | 6)65 |
| | | 1.185 | | 166 | 0898 | | 59 | 0.811 | | 61 | 1.105 | | 11 |
| | | ±0.013 | | | ±0.008 | | | ±0.008 | | | ±0.003 | | |
| Cm | 13-iv | 1.280 | | | 0.791 | | | 0.712 | | | 1.218 | | |
| | 20-iv | 1.294 | | | 0.761 | | | 0.690 | | | 1.252 | | |
| | | 2)2.574 | | | | | | | | | | | |
| | | 1.287 | | | 0.776 | | | 0.701 | | | 1.235 | | |
| Ns | 20-v | 1.270 | | | 0.746 | | | 0.736 | | | 1.246 | | |
| | 19-vi | 1.312 | | | 0.822 | | | 0.694 | | | 1.171 | | |
| | | 2)2.582 | | | 2)1.568 | | | 2)1.430 | | | 2)2.417 | | |
| | | 1.291 | | | 0.784 | | | 0.715 | | | 1.208 | | |

# Ratios in BSNA by $HClO_4$ hydrolysis.

| | Date | % NA in $HClO_4$ | Hydrol notes. | A | G OD | C | T | P recovery |
|---|---|---|---|---|---|---|---|---|
| Caulat | 25-VII-50 | 10 | 72% 1 hr BWB | 1.096 | 0.886 (162) | 0.846 | 1.137 | 101 |
| | 12-ix-50 | 8 | 72% 1 hr BWB | 1.230 | 0.896 (·11) | 0.860 | 1.017 | 98 |
| | 17-ix-50 | 16 | 72% 1 hr BWB | 1.16 | 0.93 (1.03) | 0.84 | 1.02 | 101 |
| | 19-x-50 | 11 | 72% 1 hr BWB | 1.121 | 0.898 (032) | 0.845 | 1.083 | 91 |
| Loo | 14-xii-50 | 7 | 70% 1 hr BWB | 1.13 | 0.97 (·11) | 0.840 | 1.00 | |
| | 24-i-51 | 6.3 | " | 1.12 | 0.935 (24) | 0.85 | 1.04 | 102 |
| | 21-vi-51 | 8 | 70% 2 hrs 97° | 1.121 | 0.938 (·11) | 0.827 | 1.113 | |
| | 31-vii-51 | 10 | " 100° | 1.16 | 0.95 (·19) | 0.84 | 1.00 | |
| | " | 20 | 100° | 1.15 | 0.92 | 0.87 | 1.00 | |
| | Mean | | | 1.143 | 0.924 | 0.846 | 1.044 | |
| | | | | ±0.013 | ±0.009 | ±0.004 | ±0.018 | |
| | Corrected for total | | | 1.141 | 0.922 | 0.844 | 1.042 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Caulat | 12-ix-50 | $HCO_2H$ | 1.156 | 0.877 | 0.871 | 1.099 | 89 |
| | 17-ix-50 | $HCO_2H$ | 1.14 | 0.85 | 0.855 | 1.10 | 96 |
| | 19-x-50 | $HCO_2H$ | 1.127 | 0.837 | 0.869 | 1.117 | 90 |
| Loo | ~~24~~-i-51 | $HCO_2H$ | 1.11 | 0.87 | 0.85 | 1.11 | 98 |
| | Mean | | 1.133 | 0.86 | 0.861 | 1.106 | |
| | | | | 0.858 | | | |
| | ~~Previous mean~~ | | | | | | |

BSHA-HCOOH

| | A | | | G | | | C | | | T | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.156 | +.23 | 529 | 0.877 | 19 | 361 | 0.871 | 10 | 100 | 1.099 | 7 | 49 |
| | 1.14 | +.7 | 49 | 0.85 | 8 | 64 | 0.863 | 6 | 36 | 1.10 | 6 | 36 |
| | 1.127 | -.6 | 36 | 0.837 | 13 | 169 | 0.869 | 8 | 64 | 1.117 | 11 | 121 |
| | 1.11 | -.23 | 529 | 0.87 | 12 | 144 | 0.85 | 11 | 121 | 1.11 | 4 | 16 |
| | | | 12)1143 | | | 12)738 | | | 12)321 | | | 12)222 |
| New series | 1.133 | | 95.4 | 0.858 | | 61 | 0.861 | | 27 | 1.106 | | 19 |
| | ±0.010 | | | ±.008 | | | ±0.005 | | | ±0.004 | | |
| Old series | 1.129 ± 0.006 | | | 0.851 ± .006 | | | 0.842 ± 0.011 | | | 1.126 ± 0.008 | | |
| Overall mean | 1.131 ± 0.008 | | | 0.855 ± 0.007 | | | 0.852 ± 0.009 | | | 1.116 ± 0.006 | | |
| Correct for Total | 1.130 | | | 0.854 | | | 0.851 | | | 1.115 | | |

~~HCOOH~~

Test of hydrolysis & BSNA.

| | | A | T | G | C | P recovery | N recovery. |
|---|---|---|---|---|---|---|---|
| NA 1 hr | 5-x | 1.133 | 1.054 | 0.932 | 0.826 | – | 98.8 |
| | 17-x | 1.126 | 1.091 | 0.906 | 0.824 | 94.1 | 96.7 |
| | 20-x | 1.143 | 1.024 | 0.933 | 0.844 | 95.6 | 95.4 |
| | | 1.134 (5) | 1.056 (9) | 0.924 (5) | 0.831 (2) | 94.9 | 97.0 |
| NA | | | | | | | |
| NA 2 hrs. | 5-x | 1.146 | 1.020 | 0.938 | 0.843 | – | 100.0 |
| | 17-x | 1.140 | 1.061 | 0.924 | 0.822 | 99.3 | 94.1 |
| | 20-x | 1.144 | 1.055 | 0.928 | 0.822 | 97.5 | 95.9 |
| | | 1.143 (4) | 1.045 (6) | 0.930 (1) | 0.829 (30) | 98.4 | 96.6 |
| †Prot 1 hr. | 5-x | 1.115 | 1.070 | 0.932 | 0.831 | – | – |
| | 13-x | 1.113 | 1.064 | 0.931 | 0.840 | 96.9 | – |
| | 17-x | 1.119 | 1.147 | 0.874 | 0.811 | 99.0 | – |
| | 20-x | 1.129 | 1.061 | 0.916 | 0.842 | 100.4 | – |
| | | 1.119 | 1.086 | 0.913 | 0.831 | 98.6 | – |
| †Prot 2 hrs. | 5-x | 1.100 | 1.081 | 0.926 | 0.836 | – | – |
| | 13-x | 1.117 | 1.052 | 0.936 | 0.846 | 98.1 | – |
| | 17-x | 1.117 | 1.100 | 0.902 | 0.830 | 102.0 | – |
| | 20-x | 1.141 | 1.089 | 0.876 | 0.842 | 101.2 | – |
| | | 1.119 (20) | 1.080 (1) | 0.910 (1) | 0.838 (9) | 100.4 | – |

Introduction

Discovery of variation in NA's.
Significance?
Stanley Boncheim & Bergdahl

Materials & Methods

Prep'n of pure virus. Properties of the viruses & table.
Chromatographic technique
Hydrolysis. Results & BSNA. Importance of
Inorganic analyses.

Purified NA's

| | |
|---|---|
| Bun | 9-xi-49 |
| Lound | 21-xi |
| Ld | 13-xi |
| Dp | 13-xii |
| Round | 13-xii |
| .. | 16-iii-50 |
| Lon | 24-iv-50 |
| Earthworm | 21-iii-50 |
| Ld | 19-vi-50 474 g → no yield. |
| Bun | 31-viii-50 234 g → 2.4 mg. |

(1) Temp.
(2) Conc. in HCl, etc.
(3) Added prot.
(4) Carbon residue.

Results

Table of ratios
Lack of uracil ✓
Table of constant ratios

Discussion Significance of lack of RNA

✓ TMV results & animal NA's Concept of gene-specific NA's
✓ Presence of 2 viruses in one host.
✓ Earthworm DNA, attempt & typing meth.
✓ Agreement & isolated LdVNA
✓ Value in identifying viruses.

Mean nucleotide residue weights.

| | Pd | Lm | Pcf | Ps | Ma | Md | Bm | Cpe | Cm | Ns | Ccf | BSNA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | MC 39 |
| A (313) | 664 | 771 | 776 | 836 | 915 | 915 | 918 | 936 | 1000 | 1010 | 1026 | 870 |
| T (304) | 609 | 724 | 730 | 781 | 851 | 866 | 851 | 839 | 927 | 921 | 985 | 819 |
| G (329) | 1002 | 882 | 879 | 804 | 740 | 721 | 740 | 737 | 648 | 642 | 606 | 747 |
| C (289) | 816 | 714 | 708 | 671 | 584 | 586 | 584 | 581 | 514 | 517 | 474 | 604 |
| | 3091 | 3091 | 3093 | 3092 | 3090 | 3088 | 3093 | 3093 | 3089 | 3090 | 3091 | 3069 |

A+T/G+C ratio, re-calculated as fraction of N+D constant at 40.0

| | |
|---|---|
| 0.71 | 16.6 : 23.4 |
| 0.945 | 19.4 : 20.6 |
| 1.10 | 21.0 : 19.0 |
| 1.35 | 23.0 : 17.0 |
| 1.67 | 25.0 : 15.0 |
| 1.87 | 26.1 : 13.9 |

~~cannot be fabulous must have some significance~~

| | A+T | | d | G+C | | d |
|---|---|---|---|---|---|---|
| Pd | 41.25 | | 7.35 | 58.75 | | 7.45 |
| Lm | 48.4 | 48.6 | | 51.5 | 51.3 | |
| PCf | 48.8 | | 3.8 | 51.2 | | 3.7 |
| Ps | 52.4 | | 5.0 | 47.6 | | 6.1 |
| Mq | 57.2 | | | 42.7 | | |
| Md | 57.7 | 57.4 | | 42.2 | 42.5 | |
| Bm | 57.3 | | 5.2 | 42.7 | | 4.9 |
| Cpe | 57.5 | | | 42.5 | | |
| Ns | 62.6 | 62.6 | | 37.4 | 37.4 | |
| CMh | 62.6 | | 2.6 | 37.5 | | 2.6 |
| CCf | 65.2 | | | 34.8 | | |

| | | Ratio | d | % increase | |
|---|---|---|---|---|---|
| 83 : ~~117~~ | 1 | 0.71 : 1 | | | 171 |
| ~~91 : 109~~ | 2 | [ 0.83 : 1 ] | 11 | 6.4 | 183 |
| ~~99 : 103~~ | 3 | 0.94 : 1 | 12 | 6.6 | 194 |
| 105 : 95 | 4 | 1.10 : 1 | 16 13 | 8.2 | 210 |
| ~~110 : 90~~ | 5 | [ 1.22 : 1 ] | 12 14 | 5.7 | 222 |
| 115 : 85 | 6 | 1.35 : 1 | 13 14 | 5.9 | 235 |
| ~~120 : 80~~ | 7 | [ 1.50 : 1 ] | 15 | 6.4 | |
| 125 : 75 | 8 | 1.67 : 1 | 17 | 6.8 | |
| 130 : 70 | 9 | 1.87 : 1 | 20 | 75 | |

8) 53.5

6.69

6.69 % = 1 in 15

71 : 100

40
5) 200

$71 \times \frac{40}{171}$

$$\frac{A + T}{G + C} = 0.71$$

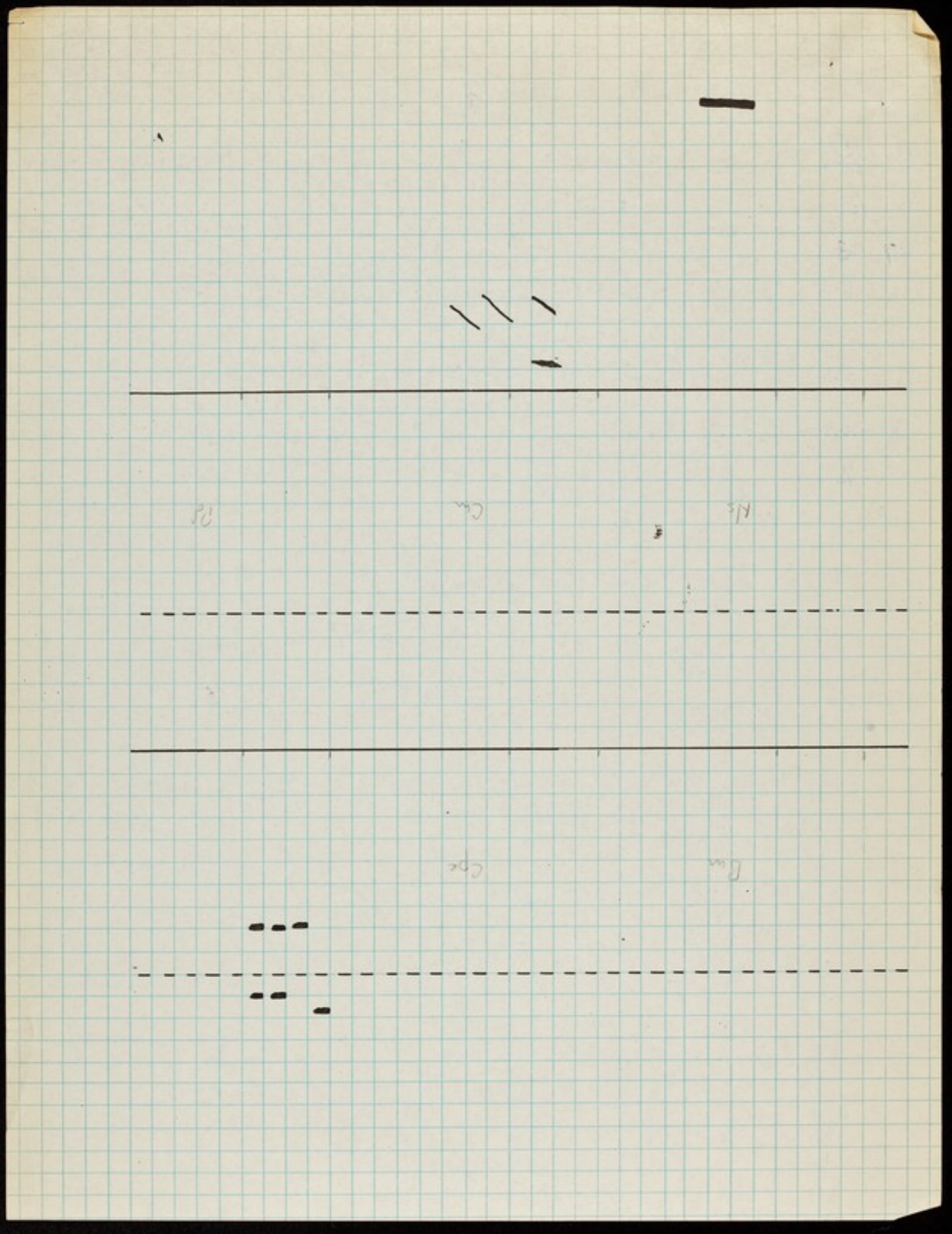
$A + T = 0.71 (G + C)$ Total = 1.71

$A + T = 0.94 (G + C)$ 1.94

$A + T = 1.10 (G + C)$ 2.10

~~171~~
283
~~294~~
311

$0.94 \times \frac{4}{194}$



| | | A | T | G | C | |
|---|---|---|---|---|---|---|
| Bm 1-xi-49 | Corr. for RNA | 1·11 | 1·20 | 0·87 | 0.82 | |
| Lm 24-ix-50 | | 1.44 | 1·43 | 0.56 | 0.68 | |
| Earlscourt 21-iii-50 | | 1·51 | 1.03 | 0·60 | 0·95 | |
| PdV new | | 0.848 | 0.802 | 1·220 | 1.130 | : 4.000 |
| PdV NA old | | 0.86 | 0.81 | 1.20 | 1.12 | |

3|19·5 / 6·5

3|16·2 / 5·4

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Properties of Insect Viruses.

| Designation | Host | Virus name | Type of inclusion body |
|---|---|---|---|
| Pd | Gypsy moth (Porthetria dispar (L.); Lepidoptera, Lymantriidae) | Borrelina reprimens Holmes | Polyhedra |
| Lm | Nun moth (Lymantria monacha L.; Lepidoptera, Lymantriidae) | Borrelina efficiens Holmes | Polyhedra |
| Bm | Silkworm (Bombyx mori L.; Lepidoptera, Bombycidae) | Borrelina bombycis Paillot | Polyhedra |
| Cpe | Alfalfa butterfly (Colias philodice eurytheme Boisd.; Lepidoptera, Pieridae) | Borrelina camptoles Stanley | Polyhedra |
| Ma | Orchard tent caterpillar (Malacosoma americanum (Fabr.); Lepidoptera, Lasiocampidae) | — | Polyhedra |
| Md | Forest tent caterpillar (Malacosoma disstria | — | Polyhedra |