Fig. 3. *Bournonia planasi.* Type specimen. × 0,27!
Fig. 4, 5. *Radiolites macroplicatus.* fig. 4: × 0,63, fig. 5: × 0,36.
Fig. 6, 8. *Bournonia planasi.* Fig. 6: vertical, radial section of the middle of the shell, × 21,5; fig. 8: horizontal section near the circumference. × 6.
Fig. 7, 9. *Bournonia* n.sp. fig. 7: radial section near body-cavity. × 21,5; fig. 9: horizontal section near the circumference. × 6.

Anatomy. — *Brain-bodyweight relation in human ontogenesis and the "indice de valeur cérébrale" of* ANTHONY *and* COUPIN. By J. ARIËNS KAPPERS. (Communicated by Prof. C. U. ARIËNS KAPPERS).

(Communicated at the meeting of September 26, 1936).

In 1926 ANTHONY and COUPIN 1) introduced an "Indice de valeur cérébrale" with the purpose of a somewhat more fertile study of brainweight development during ontogenesis than could be achieved by merely studying the simple relation between body- and brainweight.

Their index is expressed as follows. In a certain stage of ontogenesis is calculated, with the brain-bodyweight relation formula of DUBOIS 2), the weight which the encephalon should have possessed with the bodyweight which the concerned individuum really has. As we know, the formula of DUBOIS is $E = k P^r$, in which E is the weight of the encephalon, k the cephalisation coefficient, a factor which indicates the relative quantitative complexity of the brain, P the bodyweight and r the relation exponent which is approximately 0.25 comparing animals of the same species and 0.56 comparing different species. 0.25, therefore, is called the ontogenetic 3) or better the intraspecial relation exponent and 0.56 the phylogenetic or interspecial exponent 4).

As they were comparing individuals of the same species, ANTHONY and COUPIN considered it appropriate to use the intraspecial relation exponent. Furthermore they gave the cephalisation coefficient (k) the value which holds good for the adult, calculated with the intraspecial exponent. Applying this method, they calculated the brainweight which an adult specimen of the species would have, if its bodyweight should be reduced to that of the concerned stage of ontogenetic development. Their "Indice"

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1) ANTHONY, R. and COUPIN, F., Introduction à l'étude du développement pondéral de l'encéphale. L'indice de valeur cérébrale au cours de l'évolution individuelle. Zagreb (1926).

2) DUBOIS, E., On the relation between the quantity of brain and the size of the body in Vertebrates. Proc. Royal Acad. Amsterdam, **16** (1913). Idem, Phylogenetic and ontogenetic increase of the volume of the brain in Vertebrata. Proc. Royal Acad. Amsterdam, **29**, 230.

3) For the use of the word ontogenetic in this connection I refer to the Summary.

4) DUBOIS also calls the ontogenetic exponent homoneuric and the phylogenetic one heteroneuric.

The expressions intraspecial and interspecial relation exponents are introduced by ARIËNS KAPPERS, C. U. for DUBOIS' ontogenetic and phylogenetic exponents (see his Evolution of the Nervous System, Haarlem (1930), p. 203).

then is the quotient of the really observed brainweight and the brainweight resulting from this calculation. To give an example: if the calculated brainweight is 150 and the observed brainweight 200, the index is $\frac{200}{150} = 1.33$.

The authors consequently presume that during the whole ontogenesis the intraspecial relation exponent may be applied in the formula of DUBOIS and also that the cephalisation (k) remains constant. Thus they find, using data of ZIEHEN, BOYD and PARROT, that their index reaches a maximum of 1.4 during the 3d—4th year, this being its highest value during the whole ontogenesis, i.e. that the brainweight at this age is 1.4 times larger, and also so much more in qualitative value, according to ANTHONY and COUPIN, than the brainweight of an adult of the same proportion as a child of 3—4 years. After this age their "Indice" gradually decreases till the value 1 is reached with the adult age.

But why these calculations of brainweights of for the greater part fictious, impossible individuals? Why a double calculation, where in the formula of DUBOIS itself, we know a factor which reaches the purpose, aimed at by ANTHONY and COUPIN, perhaps much better? For is not the cephalisation factor, k, a certain quantitative expression of the stage of development at which the brain is standing, indicating its relative complexity? Besides, is it not far more logical and simple to use only once DUBOIS' formula to calculate by substitution of the given brain and bodyweights the cephalisation coefficients with equal relation exponents — for a moment assuming that ANTHONY and COUPIN were right in doing so — instead of making the cephalisation constant and thus creating fictive brainweights?

Applying this method it appears that, k being calculated for different ages, this cephalisation factor varies ever so much during ontogenesis. The cephalisation also reaches its highest value in the 3d—4th year, when we use the same data as the authors did, and has the same course as they found for their "Indice de valeur cérébrale".

This parallelism was to be expected as follows from some mathematical equations.

ANTHONY and COUPIN used the formula of DUBOIS in this form:

$$E_{\text{to be calculated}} = k_{\text{constant}} P^r,$$

where we will call k constant because they took the same value for it in each equation, i.e. the value of k in the adult individual of the species; the "Indice de valeur cérébrale" then is:

$$\frac{E}{E_{\text{to be calculated}}}.$$

Following the other method, i.e. calculating the cephalisation coefficient we should write the formula:

$$E = k_{\text{to be calculated}} P^r.$$

On examination of the ratio between the index and the cephalisation factor, it follows from the above mentioned equations that

$$\frac{\textit{Indice de valeur cérébrale}}{k_{\textit{to be calculated}}} = \frac{I}{k_{\textit{constant}}} = \mathrm{C}.$$

This shows that the ratio between the index of ANTHONY and COUPIN and the cephalisation factor, calculated for each non-adult individual, is constant. They are directly proportional.

As the variation of the cephalisation during growth seems to express the same as ANTHONY and COUPIN wanted to learn with their index, it seemed desirable, before refuting their startingpoints, to demonstrate the improbability of their conclusions by using the more direct and simple method of calculating the coefficient which gives the same results and whereby these may be seen more clearly.

From the calculations namely, should follow that the cephalisation, i.e. the relative complexity of the brain, would have its highest value in early youth to decrease in the further course of development.

Here we have a demonstration of the disagreeable fact that the cephalisation coefficient is only a relative factor, being used a constant relation exponent, dependent not only on brainweight but also on bodyweight. In comparing the final stages of development, i.e. adult animals, the cephalisation factor has its advantages though being relative, because it demonstrates a certain difference in organisation between animals in agreement with the natural system. On the other hand it includes a certain, more absolute value here because we deal with fullgrown brains and fullgrown bodies, the cephalisations of which are compared. Therefore one can, for instance, say that the real general complexity of the brain of man will be in all probability four times greater than the brain complexity in Anthropoids, the relative complexity of the human brain being four times greater, when we assume that the peripherical innervation is about the same in both.

But in ontogenesis we have to deal with a complicating circumstance, i.e. the own growing-rhythm of brain and body, which perhaps in time may be compared but not in quantity of weight increase per time unit 1). It is known that the development of brainweight is stopped at a much earlier stage in ontogenesis than the development of bodyweight. After this age bodyweight increases while brainweight remains practically constant. Naturally, therefore, the relative complexity, the relative cephalisation factor decreases. Now we have reason to assume that the real complexity of the brain will not much more differentiate after the stage at which the brain reaches its final weight. The fact that we find that the cephalisation factor in early youth is greater than in the adult stage shows the limits and the insufficiency in this respect of this factor

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1) ARIËNS KAPPERS, J., Brain-bodyweight relation in human ontogenesis. Proc. Royal Acad. Amsterdam 39, 871 (1936).

to give an idea of the real complexity of the brain. It is not right to say, as ANTHONY and COUPIN seem to do, that from this should follow that also the qualitative value of the brain in youth is greater than in the adult, for greater qualitative value can only be understood in connection with greater real complexity of brain and it is not conceivable that real cephalisation, real brain complexity, should ever during development have a higher degree than in the adult stage and that it should descend below a level once reached.

From this it follows, that the method of ANTHONY and COUPIN as well as the method of calculating the cephalisation with a constant relation exponent, which gives analogous results, are misleading. Neither of these methods can be of any use to us to understand the course of brain organisation during ontogenesis 1).

For this a simple, direct application of DUBOIS' formula is not sufficient, nor even possible. First of all we have to test if the assumption of ANTHONY and COUPIN, that the relation exponent during growth remains constant, holds good.

It is only possible to calculate this exponent from two distinct cases if the cephalisation factor k is equal in both, because if not, we have too many unknown factors. Thus $k_1 = k_2$ in the formulae

$$E_1 = k_1 P_1^r \text{ and } E_2 = k_2 P_2^r .$$

By substituting the known brain- and bodyweight, r is to be calculated from the formula:

$$r = \frac{log . E_2 - log . E_1}{log . P_2 - log . P_1}$$

This rule used by DUBOIS with adult specimens of different species we now will use with specimens of different ages of one species, c.q. human males. In order to avoid as much as possible the assumption that during human ontogenesis the complexity of the brain is constant, we took the following way:

Apparently two, in age very near specimens will have a much greater agreement in relative quantitative complexity of their encephalon, i.e. in cephalisation, than specimens of more differing ages. If we want to calculate the relation exponent between different ages, the age difference should be as little as possible, so that, the cephalisation being almost equal, the relation exponent can be determined according to the above-mentioned formula. The greater the increase of brainweight per time unit, the less ought to be the time difference between two specimens differing in age,

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1) The fact that ANTHONY and COUPIN found that in some lower organised Vertebrata, as for instance Sus, the "Indice" very soon after, or even at birth, reaches the value I, never to surpass that once reached value later on, only proves, that in these animals the growth relation between brain and body is earlier consolidated than in higher organised Vertebrata.

of which the relation exponent must be calculated. After birth, greater age difference will have far less influence on the real complexity of the brain than in fetal life, when the increase of brainweight goes much more rapidly.

Calculating the relation exponents during the greater part of ontogenesis, we used the most reliable data, also on account of their number, mentioned in the series collected by JACKSON ¹). Of about 800 male and female specimens of various stages of fetal life published by WELCKER and BRANDT, LEGOU, FAUCON, ARNOVLJEVIC, ANDERSON, BOYD, LOMER, MEEH, LIMAN, THOMA, OPPENHEIMER, MÜHLMANN, COLLIN and LUCIEN, BENEKE and some by himself, JACKSON made a sharp selection, using for brainweight only 316 specimens from the second intra-uterine month to birth.

In his tables he gives the average weight percentage of various organs, calculated on the average total weight in such a way that for each individual specimen for each organ of this specimen the bodyweight percentage is calculated and from this the average of all the cases in each intra-uterine month is given. He also gives the variations, adding the minimum and maximum values. Since also the absolute bodyweights are mentioned, the average absolute weight of each organ may be easily calculated from his tables.

Evidently the average weights do not represent the condition at the beginning or at the end of a month, each average being taken over a whole month. Yet the average date of the month for which the average weight figures hold good, may be calculated with a fair degree of accuracy, the more so as the average bodyweights at the end of each month are calculated after the data of AHLFELD, LEGOU, FEHLING and MICHAELIS. The curve constructed by means of these averages is the ideal mean of the curves constructed after the data of each of these authors, which do not run exactly parallel, especially not for the end of the prenatal period.

For the postnatal period we used VIERORDT's ²) figures, which were also critically selected by this author from data from various sources.

The number of brains whose weight was taken was 483, distributed over 25 years. A disadvantage of VIERORDT's means is that the figures used for making it were not first calculated individually as JACKSON did.

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¹) JACKSON, C. M., On the prenatal growth of the human body and the relative growth of the various organs and parts. The American Journal of Anatomy, Vol. IX.

²) VIERORDT, H., Daten und Tabellen für Mediziner. Jena (1906). We used these data for postnatal bodyweight, passing over those from other authors, because VIERORDT gives a complete series from birth to the 25th year, based on data from QUETELET. In comparing his data with those from others, for instance FREEMAN, R. G. Jr. (Skeletentwicklung und Wachstum im Alter von 2 bis 18 Monaten, von 2 bis 7½ Jahren und von 8 bis 14½ Jahren, Anthropologischer Anzeiger, Jhrg. X, (1933)), the weights of VIERORDT seem to be a little low, whereas those of FREEMAN, who measured American children, are a little high in comparison with data from various other authors, quoted by him. Our general results however will not be dependent on these differences.

VIERORDT's figures have been partly corrected by DONALDSON [1]). Of these postnatal data only those of the male specimens were used.

The averages of these brainweights suffer from a certain lack of exactitude by the relatively small number of specimens in some periods. This. as well as the fact that the postnatal data concern periods of a whole year and do not give the condition at the end of such a year, also explains that according to these figures the brainweight does not continually increase after birth but sometimes gives a lower average for an older year. This does not agree with what may be expected in a period of growth and apparently is due to an insufficiency of reliable data.

The way in which we combined these data and the results they gave in calculating the relation exponents may be seen from the following table:

Age:	Relation exponent (*r*):
2d — 3d intra-ut. month	0.976
3d — 4th „ „	0.883
4th — 5th „ „	0.888
5th — 6th „ „	1.042
6th — 7th „ „	0.936
7th — 8th „ „	0.787
8th — 9th „ „	1.506
9th — 10th „ „	1.027
neonat. — 1st month	2.128
1st — 2d., 3d „	0.625
2d, 3d — 4th, 5th, 6th month	0.499
4th, 5th, 6th — 7th, 8th, 9th month	0.654
7th, 8th, 9th — 10th, 11th „	1.407
10th, 11th — 1st year	1.180
1st — 1.5th „	1.079
1.5th — 1.75th „	0.794
1.75th — 2d „	0.026
2d — 3d „	0.637
3d — 4th „	1.561
4th — 6th „	0.078
5th — 6th „	0.608
6th — 8th „	0.049
7th — 8th „	0.141
8th — 9th „	0.506
8th — 10th „	0.195
10th — 12th „	0.038
12th — 13th „	0.314
13th — 15th „	0.043

From this table it plainly appears that the relation exponent during

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[1]) DONALDSON, The growth of the brain. London (1898).

human ontogenesis, so the r in the relation formula of DUBOIS $E = kP^r$, is not in the least constant and that in this way certainly neither the ontogenetic or intraspecial of 0.25, nor the phylogenetic or interspecial of 0.56 can be of any use to calculate the cephalisation during human development.

The fact that the relation between brain- and bodyweight in ontogenesis is not constant (as was well known before long from the simple varying quotient of body- and brainweight) and does not correspond either with the interspecial nor with the intraspecial relation, can still be demonstrated in another way, namely by a curve in which on the absciss are given the bodyweights in grammes from the 4th intra-uterine month till the 10th year and on the ordinate the brainweights, also in grammes (see figure).

This graph also gives the curves resulting from the relations $E \backsim P^{0.25}$ and $E \backsim P^{0.56}$ calculated and constructed from the 4th intra-uterine month, birth and the 5th year on, to which are added the straight relation lines $E \backsim P$[1]).

As stated above, the relation curves and lines are calculated from three ages on, based upon the relation between body- and brainweight conform to the formula of DUBOIS in these ages. Thus we have to compare the part of the real relation curve (strong line in the figure) from the 4th intra-uterine month till birth with the relation curves and line constructed from the 4th intra-uterine month point on. Similarly the part from birth to the 5th year with curves $E \backsim P^{0.56}$ and $E \backsim P^{0.25}$ and the relation line $E \backsim P$ constructed from the birth point on, and the same with the part between the 5th and the 10th year. It is always assumed that during these time differences the cephalisation remains constant — which in all probability does not quite hold good, certainly not in the fetal period. However, only in this way we can clearly show what we want to demonstrate.

In the above-mentioned table the cephalisation factors in the stages, between which the relation exponents are calculated, are considered to have the same value, this being necessary for calculating the relation factor for the purpose of interpolating it in the formula of DUBOIS, which, without doing so, would not be possible.

It now appears that in older stages the real relation curve is leaving the relation lines $E \backsim P$, to which it was very near, especially in the beginning of the fetal period of development[2]), to approach more and more the relation curve $E \backsim P^{0.56}$ in the complex, calculated from birth on, while in the complex calculated from the 5th year the real curve is very near the relation curve $E \backsim P^{0.25}$. On the ground of known histological data, we may assume that the complexity of the brain certainly will not develop

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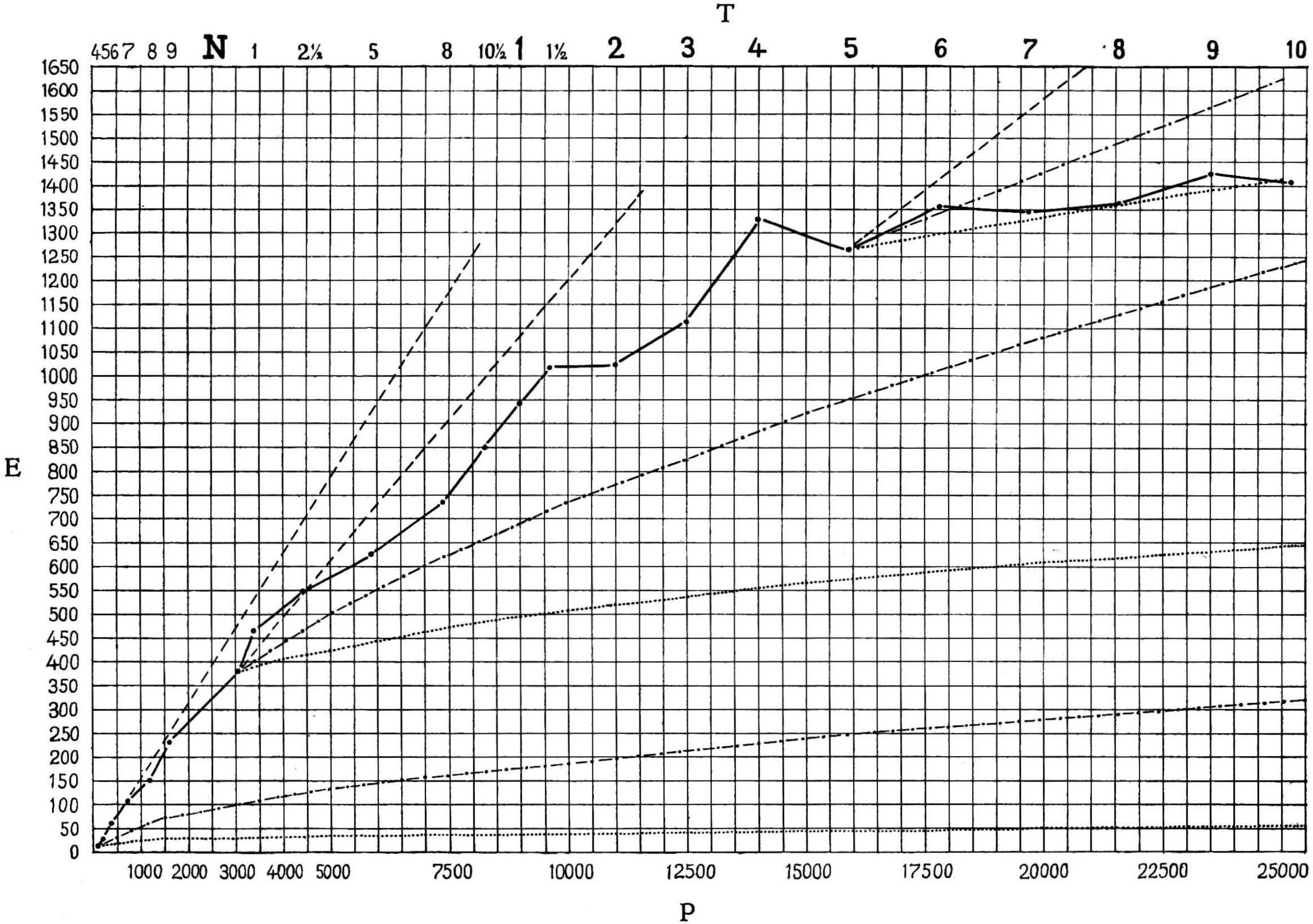
[1]) For brain-bodyweight relation equations and their percentual increase during ontogenesis see also ARIËNS KAPPERS, J., l.c., p. 871.

[2]) This also appears from the above-mentioned table, where the relation factor is very near I and widely exceeds even the interspecial relation exponent.



Graph of the relationcurve (strong line) of body- and brainweight form the 4th intrauterine month till the 20th year. Bodyweight (*P*) on the absciss, brainweight (*E*) on the ordinate, both in grammes; after JACKSON's and VIERORDT's data. Parallel to the absciss time (*T*) is given in intrauterine months (till *N*), months (till 1), and years (1—10).

Broken lines: relationlines $E \sim P$. Dashed-dotted lines: relationcurves $E \sim P^{0.56}$. Dotted lines: relationcurves $E \sim P^{0.25}$.

much more in the course of ontogenesis after the 5th year, so that from this age on we may regard the cephalisation, i.e. here the real complexity of the brain, as constant. And so we see that ANTHONY and COUPIN's assumption that the ontogenetic relation exponent may be used during human ontogenesis is approximately correct only for the period of 5—10 years, i.e. only from the time that cephalisation became constant. After the 10th year, when brain growth stops, whereas the body more than doubles its weight, this method of graphic demonstration evidently can no more be applied.

If we would assume theoretically that at least in the beginning of ontogenetic development the relative complexity of the brain, its cephalisation, still more increases, so that between the 4th intra-uterine month and birth and between birth and the 5th year cephalisation would not be constant as we assumed for convenience sake in constructing our figure, then the designed relation curves of $E \backsim P^{0.25}$ and $E \backsim P^{0.56}$ and also the relation $E \backsim P$ would run somewhat higher and acquire a slightly different shape. But nevertheless the deviation of the real relation curve from the curves with the higher relation exponents and its approach to those with the lower exponents during the ontogenetic course would be as clear as it is now.

From the further difficulties involved in this subject we mention only the fact that in the used formula the relation exponent is a potential of the bodyweight, so that it is clear that not only the absolute value of the cephalisation coefficient will depend upon the exponent, but that also the relation between different cephalisation coefficients will differ according to the relation exponent used for their calculation.

From all this it follows that it will not be easy to express the change in quantitative complexity of the brain during ontogenesis in such a simple way as DUBOIS could do this for phylogenetically different adults.

SUMMARY.

From our calculations, substituting JACKSON's and VIERORDT's data for body- and brainweight during ontogenesis in the brain-bodyweight relation formula of DUBOIS, and from the graphical composition of these data it appears that the assumption of ANTHONY and COUPIN, that the relation exponent between body- and brainweight used in calculating their "Indice de valeur cérébrale" may be considered to remain constant during ontogenetic development and should be the intraspecial one, does not hold good.

On the contrary the brain-bodyweight relation is very variable also as far as the relation exponent is concerned, so that neither the intraspecial nor the interspecial or any other constant relation exponent could be used in calculating cephalisation during ontogenesis.

It is demonstrated that also in other respects their conclusions must be considered as erroneous.

The relation exponent during ontogenesis not being constant, it is not right to call the intraspecial exponent (± 0.25) — which only holds good for adults in comparison with adults of the same species — the ontogenetic exponent.

Psychology. — *Die psychoanalytische Trieblehre.* Von G. RÉVÉSZ. (Psychologisches Laboratorium der Universität Amsterdam). (Communicated by Prof. E. D. WIERSMA).

(Communicated at the meeting of September 26, 1936).

Die Aufgabe, die ich mir stelle, ist, die FREUD'sche Lehre über die Triebe in ihrer Entwicklung zu verfolgen, auf ihre Konsequenzen zu prüfen und seine Aufstellungen mit den normalpsychologischen Erfahrungen und den allgemein-biologischen Tatsachen zu konfrontieren.

1. DIE URSPRÜNGLICHE TRIEBLEHRE.

Das Primat des Sexualtriebes.

In seinen „Vorlesungen zur Einführung in die Psychoanalyse" (1920) bezeichnet FREUD den Trieb zur Nahrungsaufnahme und den Trieb zur sexuellen Betätigung als die beiden wichtigsten Lebensfunktionen. Er setzt dem Hunger die Libido gegenüber, worunter er jene Kraft versteht, „mit welcher der Trieb, hier der Sexualtrieb, wie beim Hunger der Ernährungstrieb, sich äussert" (S. 357). Trotz des Unterschiedes stehen nach FREUD beiden vitalen Funktionen nicht scharf getrennt einander gegenüber, wie die alltägliche Erfahrung und die Psychologie der Lebensbedürfnisse lehren, denn schon in der ersten Periode des Lebens kann man im Akt des Saugens die Verbindung beider Fundamentaltriebe feststellen, indem der Sexualtrieb sich in der „Anlehnung" an den Nahrungstrieb manifestiert.

Wenn wir auch zugeben, dass sexuelle Erregungen schon in der frühesten Kindheit hervortreten und dass sie im Saugen des Säuglings ihren Ausdruck finden, selbst in diesem Falle muss gewarnt werden, die beiden Triebe etwa als Modifikationen *eines* Grundtriebes anzusehen, — eine Auffassung, wozu das FREUDsche Lustprinzip und die verschiedenen Formen der Libido leicht Anlass geben könnten. Denn aus dem Umstand, dass ein Körperorgan zweierlei Bedürfnissen dient, folgt noch nicht, dass diese Bedürfnisse auch wesensverwandt sind. Es bleibt doch noch immer die Möglichkeit zu erwägen, ob beim Säugling das Saugen nicht etwa ein Generalmittel ist, den gespannten Zustand des *ganzen* psychophysischen Systems ins Gleichgewicht zu bringen. Es ist nämlich nicht auszuschliessen, dass ein Ausgleich, eine Entspannung immer erfolgen kann, sobald das Energiereservoir an irgendeiner Stelle des