the ablative in medicine titles are therefore fixed, and the ablatives so occurring are easily learned by rote.

The *expression* of case is, in Latin, effected by modification of the ending of the word itself which is to be declined, and in such modification, *adjectives* share as well as nouns.. Different modifications are employed to signify case in the singular and plural number, respectively, and of such modifications there are, in ordinary, five distinct systems, constituting the five several *declensions* of nouns and adjectives, besides cases of irregular declension presented by certain pronouns and cardinal numerals. Of the five systematic declensions, one, the *fifth*, affords but a single example in prescription Latin, namely, the ablative *re* of the noun *res* in the oft-quoted phrase *pro re natâ*. Of the other four declensions, examples occur in prescription-writing of the *nominative*, *genitive*, *accusative*, and *ablative* cases, respectively, in the singular number, and of the *nominative*, *genitive*, and *accusative* in the plural. The following table shows the endings for the several cases so enumerated, so far as concerns nouns and adjectives embraced in the prescriber's vocabulary. Endings for nouns not in such vocabulary are purposely omitted, as are also the irregular declensions of pronouns. In the table the italicized letters *m.*, *f.*, and *n.*, signify respectively, that the case endings in the columns beneath are those of nouns or adjectives of the *masculine*, *feminine*, or *neuter* gender; for, as appears in the table, case endings often differ, even in the same declension, according to the gender of the word. The endings of the first and second declensions, severally, which appear *in parenthesis*, are the endings of certain Greek nouns, adopted into Latin with something of the Greek form retained. The table also gives a list of words of foreign origin applied as drug titles, which, following the Latin idiom in such case, make no change of ending to signify case—are, in short, *indeclinable*.

TABLE OF PARTS OF LATIN DECLENSIONS SO FAR AS EXEMPLIFIED BY WORDS USED IN PRESCRIPTION-WRITING.

1. *Regular Declensions of Nouns and Adjectives.*

	First declension.	Second declension.		Third declension.		Fourth declension.
	f.	*m.**	*n.*	*m. and f.*	*n.*	*m.*†
SINGULAR.						
Nominative	-a (-e)	-us (-os)	-um (-on)	(various)	(various)	-us
Genitive ...	-æ (-es)	-i		-is		-ûs
Accusative .	-am (-en)	-um (-on)		-em	(like nom.)	-um
Ablative ...	-â	-o		-e		
PLURAL.						
Nominative	-æ	-i	-a	-es	-a	-us
Genitive ...	-arum	-orum		-um, -ium		-uum
Accusative .	-as	-os	-a	-es	-a	-us

(Fifth Declension exemplified only in ablative singular *re* in phrase *pro re natâ*.)

*Except *juniperus*, *prunus*, *rhamnus*, *sambucus*, and *ulmus*, feminine.

†Except *quercus*, feminine.

2. *Declension of Cardinal Numerals.*

	Unus, One.			*Duo*, Two.			*Tres*, Three.	
	m.	*f.*	*n.*	*m.*	*f.*	*n.*	*m. and f.*	*n.*
Nominative	un-us	-a	-um	du-o	-æ	-o	tr -es	-ia
Genitive ...	-ius			-orum	-arum	-orum	-ium	
Accusative .	-um	-am	-um	-os	-as	-o	-es	-ia

All other cardinal numerals are indeclinable.

INDECLINABLE DRUG-TITLES—*all neuter.*

Alcohol,	Catechu,	Eucalyptol,
Amyl,	Chloral,	Kamala,
Buchu,	Cusso,	Kino,
Cajuputi,	Elixir,	Matico,

INDECLINABLE DRUG-TITLES—*all neuter.—Continued.*

Menthol,	Pyrogallol,	Sumbul,
Methyl,	Salol,	Thymol.
Naphtol,	Sassafras,	

As appears at a glance from the foregoing table, in the case of any noun or adjective belonging to either of the three declensions numbered as *first*, *second*, and *fourth*, respectively, if the *nominative* be given, any other case can at once be formed by substituting the proper case ending for that of the nominative. In words of the *third* declension, however, this possibility in very many cases does not obtain. For in this declension the *nominative* often stands apart from the other cases in the way of having the very root, or "stem," of the word curtailed or modified in its construction. Thus, the stem *anthemid-*, giving genitive *anthemidis*, accusative *anthemidem*, and ablative *anthemide*, gives nominative *anthemis*—a word in which the full stem does not appear. Similarly, the root *flor-*, giving genitive *floris*, etc., gives nominative *flos*; and root *rho-*, giving genitive *rhois*, offers the much modified nominative form *rhus*. Hence, for the proper rendering in oblique case of nouns or adjectives of the *third* declension, it becomes necessary to learn arbitrarily the form of some one of the oblique cases—most conveniently the genitive—as well as that of the nominative.

A special point concerned in the expression of case obtains in the case of *adjectives*, to the effect that very many of these words form their case endings after different ones of the declension models, according to the *gender* of the noun to which the adjective is attached. In compound drug titles, therefore, which include an adjective, the gender of the noun modified by the adjective becomes necessary to know for the *intelligent*, proper rendering of the adjective's case ending. Of course, such knowledge is not essential, since the title, adjective, and all, can be learned by rote, and then, remembering the nominative form of the adjective, the necessary change to genitive or accusative, to suit the requirement of the prescription phrase, can be done by rule. But it saves a vast amount of unnecessary memorizing to understand the system, so far as system goes, by which genders of Latin nouns are determined. Reverting, then, to the above declension table, it appears that all prescription occurring nouns of the *first* declension are *feminine* in gender; all those of the *second* declension ending in *-um*, or *-on*, are neuter, and, with a few exceptions, all of the *second* declension ending in *-us*, or *-os*, and all of the *fourth* declension ending in *-us*, are *masculine*. The exceptions in the two latter instances are nouns in *-us*, representing ancient Latin *tree-names*, which, because of the ancient Latin conception of an inherent femininity in trees as things, take the feminine gender in spite of their etymologically masculine nominative ending. In the *third* declension all genders appear, and, although in nouns of certain nominative endings the ending carries with it the gender, yet in the case of many other nouns this is not so, and genders must be learned arbitrarily. Happily, however, the number of nouns of the third declension, among drug titles, which bear an associated adjective, are quite few.

From the above analysis it is evident that, in the case of a given *noun* in the nominative, the rendering of the same in an oblique case can proceed by rule according to the foregoing declension table, if only the declension of the noun be known; with the further item, in the instance of a noun of the *third* declension, that some one oblique case, as well as the nominative, be known, for the affording of the full stem of the word. Similarly, the proper case dress of any given *adjective* can be fixed if the scheme of declension of the adjective itself be known, on the one hand, and, on the other, the gender of the noun to which the adjective is to be affixed—adjectives requiring to agree with their respective nouns in gender, number, and case. This requisite information concerning nouns and adjectives of prescription use is afforded in the two following tables—the one giving a key to the declensions of nouns, with genders, and also, in the case of nouns of the third declension, genitive endings—and the other showing the schemes of declension of adjectives.

TABLE SHOWING DECLENSION AND GENDER OF NOUNS OCCURRING IN TITLES OF U. S. PHARMACOPŒIAL MEDICINES AND IN COMMON PRESCRIPTION TERMS.

Nominative singular ending in **-a:**

All First Declension and Feminine, except (of Greek origin) *the following* in *-ma:*

Physosti'gma (physostig'matis), 3*d*, *n*.	Catapla'sma (catapla'smatis), 3*d*, *n*.
Aspidospe'rma (aspidospe'rmatis), 3*d*, *n*.	Gargari'sma (gargari'smatis), 3*d*, *n*.
E'nema (ene'matis), 3*d*, *n*.	Theobro'ma (theobro'matis), 3*d*, *n*.

Nominative Singular ending in **-us:**

All Second Declension, Masculine, except—

Juni'perus, 2*d*, *f*.	Rhus (rho'is), 3*d*, *f*. ("rhus glabra").
Pru'nus, "	Fru'ctus, 4*th*, *m*.
Rha'mnus "	Spi'ritus, "
Sambu'cus, "	Que'rcus, "
U'lmus, "	

Nominative Singular ending in **-os:**

Comprise only the following—

Flos (flo'ris), 3*d*, *m*.	Bos (bo'vis), 3*d*, *m*. or *f*.

Nominative Singular ending in **-um:**

All Second Declension, Neuter.

Nominative Singular ending in **-on:**

Comprise only the following—

Eriodi'ctyon, 2*d*, *n*.	Eri'geron (erigero'ntis), 3*d*, *n*.
Hæmato'xylon, "	Li'mon (limo'nis), 3*d*, *m*.
Toxicode'ndron, "	

Nouns of all other endings are of Third Declension, and are as follows:

Ending in **-c:**

Lac (la'ctis), *n*.

Ending in **-el:**

Fel (fe'llis), *n*.	Mel (me'llis), *n*.

Ending in **-en:**

Alu'men (alu'minis), *n*.	Se'men (se'minis), *n*.

Ending in **-o:**

(*-io*)	(*-ago*)
Confe'ctio (confectio'nis), *f*.	Mucila'go (mucila'ginis), *f*.
Lo'tio (lotio'nis), *f*.	(*-bo* and *-po*)
Po'rtio (portio'nis), *f*.	Ca'rbo (carbo'nis), *m*.
Tritura'tio (trituratio'nis), *f*.	Pe'po (pepo'nis), *m*.
	Sa'po (sapo'nis), *m*.

Ending in **-r:**

(*-er*)	(*-or*)
Æ'ther (æ'theris), *m*.	Li'quor (li'quoris), *m*.
Pi'per (pi'peris), *n*.	(*-ur*)
Zi'ngiber (zingi'beris), *n*.	Su'lphur (su'lphuris), *n*.

Ending in **-s:**

(*-as*, genitive *-atis*)	(*-is*, genitive *-eris*)
Ace'tas (aceta'tis), *m*.	Pu'lvis (pu'lveris), *m*.
[*and all salt-names in -as.*]	(*-is*, genitive *-is*)
	Ca'nnabis (ca'nnabis), *f*.
(*-as*, genitive *-adis*)	Digita'lis (digita'lis), *f*.
Ascle'pias (asclepi'adis), *f*.	Hydra'stis (hydra'stis), *f*.
(*-is*, genitive *-itis*)	Sina'pis (sina'pis), *f*.
A'rsenis (arseni'tis), *m*.	
[*and all salt-names in -is.*]	(*-os*, *see ante.*)
(*-is*, genitive *-idis*)	(*-us*, *see ante.*)
A'nthemis (anthe'midis), *f*.	(*-ns*)
Ca'ntharis (cantha'ridis), *f*.	Ju'glans (jugla'ndis), *f*.
Colocy'nthis (colocy'nthidis), *f*.	(*-ps*)
Hamame'lis (hamame'lidis), *f*.	A'deps (a'dipis), *m*.
I'ris (i'ridis), *f*.	(*-rs*)
Ma'cis (ma'cidis), *f*.	Pars (pa'rtis), *f*.

Ending in **-x:**

(*ax*)	(*-ix*)
Bo'rax (bora'cis), *m*.	Pix (pi'cis), *f*.
Sty'rax (styra'cis), *m*.	Ra'dix (radi'cis), *f*.
(*-ex*)	(*-ux*)
Co'rtex (co'rticis), *m*. and *f*.	Nux (nu'cis), *f*.
Ru'mex (ru'micis), *f*.	(*-lx*)
	Calx (ca'lcis), *f*.

TABLE SHOWING SCHEMES OF DECLENSION AND GENDER OF ADJECTIVES OCCURRING IN U. S. PHARMACOPŒIAL MEDICINAL TITLES AND IN PRESCRIPTION-PHRASES.

SCHEME I.—*Second and First Declensions Combined.*

Masculine.	*Feminine.*	*Neuter.*
-us [2d dec.]	*-a* [1st dec.]	*-um* (*-on*) [2d dec.]

SCHEME II.—*Third Declension.*

Masculine and Feminine.	*Neuter.*
-is (genitive *-is*).	*-e* (genitive *-is*).

SCHEME III.—*Third Declension.*

Masculine and Feminine.

-or (genitive *-oris*).

SCHEME IV.—*Third Declension.*

All Genders.

-ens (genitive singular *-entis*); (genitive plural *-entium*).

In commentary upon the declension schemes of adjectives set forth in the foregoing table, it may be stated that Scheme I. embraces by far the greater number of adjectives. In this scheme the neuter ending *-on*, borrowed from the Greek like the same ending among nouns of the second declension, finds among drug titles but a single example, *diachylon*. Scheme II. embraces a few adjectives only among those occurring in medicine titles, and affords an example of the nominative ending *-e* of the third declension, which does not occur among *nouns* of pharmacopœial titles. Scheme III. offers a single example only, viz., *fortior*. Of Scheme IV. pharmacopœial adjectives give but two examples, namely, *effervescens* and *recens*. A survey of the *genders* marked on the table shows that in every case a distinctive gender, where there is such, can be told from the adjective nominative ending.

A final point, concerning the expression of a prescription, is that, having regard to the fact that a *slip of the pen* on the part of the writer, or a *slip of the understanding* on the part of the pharmacist reader of a prescription, may convert what was meant as a missive of mercy into a death warrant, it behooves the prescriber most solemnly to execute his task *deliberately*, *thoughtfully*, and, in chirography, *legibly*, *abjuring all dangerous cloak-of-ignorance abbreviation of medicine-titles*; and, finally, to fail not of that trusty safeguard against error, a *review of the paper* after the writing. *Edward Curtis.*

PROTOZOA.—Standing distinctly as the lowest of all animal organisms, the protozoa constitute a branch differentiated from higher groups by the simplicity of organization in that the animal consists of but a single cell or a colony of simple cells. In the main the animals of this group are easily recognized, although some forms are so generalized, and partake of plant characteristics to such an extent as to render their classification doubtful; and, on the other hand, certain higher forms show the first stages in specialization among cells of the colony which ultimately leads to the differentiation of the metazoan organism.

The Protozoa are true cells and possess consequently neither organs nor tissues. In the discharge of all living functions by the single cell, however, one finds a physiologic complexity as striking as the morphologic simplicity. The latter is also less extreme in many cases where specialization has effected the production of individual features within the single cell, differentiations which subserve particular functions, and which are thus analogous to the organs of the metazoa. Such are denominated cell organs, or organellæ, and are of great variety. Among these may be mentioned the locomotor structures, such as pseudopodia, flagella, and cilia, the numerous vacuoles of a nutritive and contractile type, the preformed, often highly modified openings for ingestion of food and egestion of solid waste matter, and various protective coverings of a permanent character or temporary and connected with reproduction.

As true cells all Protozoa possess one or more nuclei, and the earlier contention that there exists a special group of anuclear organisms, the monera of Haeckel, has not been confirmed by later study. The simple protozoon is with a single known exception (*Loxodes rostrum*) uninuclear, and the presence of many nuclei points to a colonial organism or to a reproductive phase, except that in one large group two forms of nuclei coexist and divide the functions otherwise resident in the single nucleus.

The reproduction of the Protozoa is again that of the cell, viz., by division, which may be simple or multiple, and in varied form, either while free or in the encysted condition. Two types of division may alternate regularly or indefinitely in the life cycle of a given species, and in most subdivisions of the group certain so-called sexual processes have been demonstrated. These consist in general in the fusion of similar individuals (isogametes), or of dissimilar (macro- and microgametes), or merely in the mutual exchange of nuclear matter.

In regard to location parasitism among the Protozoa affords conditions not found otherwise. There are in this group not only organ parasites, as in the groups of helminthes, but also such forms as must be designated tissue parasites, cell parasites, and even nuclear parasites. Different phases in the life cycle of the same species may illustrate different modes of parasitism, as is the case with the malarial organisms, which at various epochs in the life history are successively cell parasites in the erythrocytes, organ parasites in the blood-vessels, and tissue parasites in the wall of the mosquito's midgut.

In general, however, the protozoan parasites repeat conditions already described for Metazoa. One finds the degeneration of organs superfluous under conditions of parasitic existence, the formation of organs of attachment, such as hooks, suckers, etc., the noteworthy fecundity already commented upon for metazoan parasites; and finally the alternation of generations and of hosts is a common feature among the Protozoa also.

An encysted condition of the entire individual or of a group of spores aids in the dispersal of the species, which are all inhabitants of a moist environment and cease activity at once on withdrawal of the water. This general habit renders it difficult to distinguish between mere commensals which find in the alimentary canal of higher forms conditions for their ordinary slime-inhabiting existence without exerting any influence upon the host, and such as are parasites in the true sense.

A true parasite draws its nourishment from the host and affects it at least to that extent. When this takes place, as with protozoan parasites largely, within a tissue or even a cell, morbid conditions are evoked, even though they remain local in some cases. That functional disturbances result is evinced by the relatively large number of protozoan diseases among animals and plants. These sometimes take the form of tissue proliferations, as has been clearly demonstrated for plants. An effort to trace similar effects in animals is found in the extensive literature on cancer parasites. Thus far, however, no sufficient evidence has been brought to establish the parasitic nature of such abnormal growths, and none of the supposed "parasites" can be clearly recognized as Protozoa. It should be noted in passing that in addition to the mechanical effect of cell parasites a chemical influence of at least equal importance is exercised by the excretions of the organism, the metabolic products set free in the protoplasm of the host cell. In some cases this is a factor of great importance, as also in the case of bacterial diseases; its significance among Protozoa is not yet sufficiently investigated.

It is noteworthy that in many instances a protozoan infection is self-terminating, either that a type of immunity is acquired by the host, or that the reproductive cycle of the parasite reaches its limit without a change of host or alternation of generations. MacNeal and Novy have recently endeavored to determine experimentally the possibility of securing attenuated cultures of one protozoan parasite (*Trypanosoma*) with absolutely negative results; the last generation from a culture more than a year old was even more virulent than the organism at the start.

Regarding means of infection but little definite evidence is at hand. It is inferred that encysted forms furnish the ordinary means for transferring the species to a new host, and yet in many cases experiments along this line have been without results. In other cases it is now known that the transfer takes place through some biting insect, which in some cases, if not all, acts as the host for another phase in the life history of the parasite, and is capable of transmitting the disease only after a period sufficient to allow of the development within its body of the specified portion of the life cycle.

In those cases in which the life history has been worked out, means of preventing the infection of the human host constitute the evident limitation to the spread of the disease caused by the parasite. The inauguration of a simple but effective prophylaxis for malaria and yellow fever ranks rightly as among the most brilliant achievements of scientific medicine. In cases in which the life history of the parasite is unknown, the prophylaxis is necessarily vague and uncertain. It is wise to emphasize here the importance of co-operative effort on the part of trained observers, both in medicine and in zoology, to elucidate fully the problems which necessarily offer almost insuperable obstacles to the investigator approaching them from the single standpoint.

All the varied modifications within the branch of Protozoa may be grouped into four well-defined classes which are now almost universally recognized. These may be briefly outlined together with their major subdivisions, following in the main the classifications of Bütschli, Calkins, and Doflein, and noting principally those groups which contain forms found in the human body.

Class I. Sarcodina.—Naked or shelled Protozoa, characterized in the free adult condition by the formation of changeable processes of protoplasm as organs of locomotion. These pseudopodia may be lobose, digitate, reticulate, or finely radiate, and may be formed over the entire surface of the body, or only at definite points. Reproduction takes place by simple division and by spore formation.

Subclass 1. Rhizopoda. Naked or shelled Sarcodina, having lobose or reticulate pseudopodia. The young may be flagellate as well as amœboid, and are produced by multiple division of the active cell or during encystment. Included among Amœbina are naked forms (Gymnamœbina) with both free and parasitic species, and also shelled forms (Thecamœbina) only free living.

Subclass 2. Heliozoa. Naked or shelled Sarcodina, typically spherical, with little change of form by amœboid movements. Pseudopodia fine, filiform, radiating from all parts, provided with axial filament and rarely changeable, exclusively free living forms.

Subclass 3. Radiolaria. Marine Sarcodina with pseudopodia like those of Heliozoa, but always provided with internal chitinous capsule which encloses the nuclei. Skeleton of acanthin or silica sometimes absent. A very large group of free living forms.

Subclass 4. Mycetozoa. Terrestrial saprophytic or parasitic forms, also known as Myxomycetes or slime moulds, and included under the fungi by some botanists. The motile amœboid or flagellate swarm spores, the plasmodia or colonies formed by the fusion of numerous amœboid individuals, and the holozoic mode of nutrition are characteristically animal features. On the other hand, the production of spores in sporangia, often provided with stalks and other plant-like structures, are taken to prove the plant nature of these forms. All known parasitic forms in this group attack plants.

Class II. Mastigophora.—Protozoa of variable form, naked or with cell membrane; they move by flagella, which vary in number from one to eight on each cell.* Mouth, contractile vacuole, and definitely formed nucleus usually present. Small forms with tendency to formation of colonies.

Subclass 1. Flagellata. Small organisms with one or more flagella at anterior end, usually actively motile, but capable of encystment. Reproduction by longitudinal fission of free form or by multiple division in encysted stage. Rarely transverse fission occurs.

Subclass 2. Dinoflagellata. Naked or shelled forms with two flagella, one of which extends out from the body, while the other is wrapped around the animal. No parasitic forms.

* *Multicilia lacustris* Cienkowsky has many flagella, distributed over the whole body.

Subclass 3. Cystoflagellata. Large marine forms with parenchymatous protoplasm and firm membrane; marine; no parasitic forms.

Class. III. Sporozoa.—Exclusively parasitic forms, in the adult condition without flagella or cilia, contractile vacuole, and opening for ingestion of solid food. Reproduction always by spore formation, usually within a firm membrane. Alternation of generations only exceptionally wanting. The young forms regularly begin the life cycle as cell parasites; other stages may be the same, or tissue or organ parasites.

Subclass I. Telosporidia.—At the end of a vegetative period the entire cell divides into sporocysts.

Order 1. Gregarinida. Vegetative stage intracellular at first, full-grown organism extracellular; fertilization isogamous, fertilized forms permanently extracellular. A large group of forms parasitic in alimentary and body cavities of invertebrates.

Order 2. Coccidiomorpha. Vegetative stage permanently intracellular; fertilization anisogamous; sexual generation permanently or temporarily intracellular. Many of the most important protozoan parasites of man fall in the limits of this group.

Subclass 2. Neosporidia.—Sporocysts are produced continually and at the expense of only part of the cell. In general these forms are not well known.

Order 1. Cnidosporidia. The spores possess one or more polar capsules which contain a coiled thread like a nematocyst. The sub-orders are: (1) Myxosporidia, parasitic in water-inhabiting vertebrates; and (2) microsporidia in certain invertebrates also. Both are not important here.

Order 2. Sarcosporidia. Parasitic in muscle cells of terrestrial vertebrates, probably without polar capsule. Little known, but important.

Class IV. Infusoria.—Protozoa with motor organs in the form of cilia, whether simple or united into membranes, membranellæ, or cirri; with macro- and micronucleus; reproduction by division and by budding, combined with an exchange of nuclear matter known as conjugation.

Subclass 1. Ciliata. Cilia persistent except when encysted. Cytostome usually present. Mostly free forms; some parasites of man and other animals.

Subclass 2. Suctoria. Cilia only on young swarming stage. Food taken in by special sucking tubes; no cytostome. No human parasites.

According to this classification the forms which have been reported from man may be arranged as given in the following list, in which, however, chiefly those species are included which are definitely accepted. Some few doubtful forms of special significance are listed here; and still others are referred to in the text under general headings.

Class Sarcodina.
  Subclass Rhizopoda.
    Order Amœbina.
      Suborder Gymnamœbina.
        Entamœba coli.
        Entamœba histolytica.
        Amœba Miurai.
        Leydenia gemmipara.
Class Mastigophora.
  Subclass Flagellata.
    Order Protomonadina.
      Cercomonas hominis.
      Monas pyophila.
      Trypanosoma gambiense.
      Cystomonas urinaria.
  Order Polymastigina.
      Trichomonas vaginalis.
      Trichomonas intestinalis.
      Lamblia duodenalis.
Class Sporozoa.
  Subclass Telosporidia.
    Order Coccidiomorpha.
      Suborder Coccidia.
        Eimeria Stiedæ.
        Eimeria hominis.
        Eimeria bigemina.
      Suborder Hæmosporidia.
        Plasmodium malariæ.
        Plasmodium vivax.
        Plasmodium immaculatum.
  Subclass Neosporidia.
    Order Sarcosporidia.
      Sarcocystis Lindemanni.
Class Infusoria.
  Subclass Ciliata.
    Order Holotricha.
      Chilodon dentatus.
    Order Heterotricha.
      Nyctotherus faba.
      Balantidium coli.
      Balantidium minutum.

The relation of the Protozoa to disease is only just beginning to be investigated. At every point the student is met by the gross insufficiency of present knowledge; a host of isolated observations is on record. Some are clearly wrong, while others are indicative of important discoveries, though the presence of certain organisms during specific diseases needs confirmation, and equally their relation to the inception and progress of the malady. New methods must be worked out for the culture no less than the study of these forms, and the same sort of rigorous analysis is demanded in demonstrating their relation to disease which has been given to bacteria. It seems altogether probable that they will play a prominent rôle in medical investigation in the near future, but in the present state of our knowledge any review of the group must necessarily be only a tentative one.

The class of Sarcodina, or sarcode animals, is typically represented by the common free-living amœba, which has its parallel in the white blood cells. The most characteristic structural feature is the ability to protrude a portion of the body substance in the form of a process or pseudopodium by which locomotion is achieved, and also the food particles are seized and engulfed. The subdivision of the class rests primarily upon the precise character of the pseudopodia.

Under the order Amœbina are included such forms as possess lobose pseudopodia, and the sub-order of Gymnamœbina embraces such of these as are without a shell. All the human parasites which fall within the Sarcodina are included in a few closely related genera of this suborder. While the structure is simple, and in agreement with that of the simple free-living forms of the group, it is impossible to demonstrate that this is not the result of degeneration from more highly differentiated forms by virtue of the parasitic mode of existence. The parasitic species are most probably to be traced back to slime-inhabiting, free-living forms, a transition from which to the present parasitic existence seems most immediate and simple in physiological adjustment.

The ordinary method of reproduction is by simple division, recurring at frequent intervals and conserving the rapid multiplication of the species. This form has long been known, and is to be observed frequently in all truly independent organisms of this type. Recent investigations have disclosed another reproductive type: under definite circumstances, possibly only after fusion of individuals or some exchange of nuclear matter, the amœba forms a cyst within which the nucleus undergoes multiple division, and ultimately the protoplasm arranges itself about the new nuclei, so as to give rise to an equal number of small amœbæ. When these desert the cyst there is left behind a residual mass of protoplasm. At first distinguishable slightly in structure as well as size, the small amœbæ thus produced soon grow to the size and appearance of the adult. The occurrence of this stage in the life cycle has not yet been demonstrated for parasitic amœbæ, except very recently for *Entamœba coli* and *E. histolytica*; but if present it may well be related to the spread of the species as found in the change of hosts. The necessity for such a stage would explain the ineffectual attempts which have been made to inoculate new hosts by direct transference of the ordinary parasitic form.

In the genus *Amœba* the separation of species is exceedingly difficult on account of the insignificant features available for purposes of differentiation. There are those who lump the forms found in man with such as occur in other mammals under a single species, and there are also those who contend that each host shelters a distinct parasitic species, and bring as evidence the individuality of parasitism in other groups. But on the other hand it may be urged that the amœbæ are not highly differentiated as parasites, and mere difference in host animal has long since been abandoned as a distinguishing mark between parasites from higher classes. It is certain that no positive statement can be made until more complete information is obtained regarding the life cycle of the species. At present no one can affirm that a given species does not possess a free-living generation as well, or even that it is not a normal free-living form which under favorable circumstances has taken up the parasitic mode of life; in which case it should be regarded as a mere accidental parasite. Furthermore of only one human parasite included within this group can it be said positively that it is more than a harmless commensal. Although facts have been adduced to show that others also play a pathogenic rôle, the question must still be regarded as at least an open one.

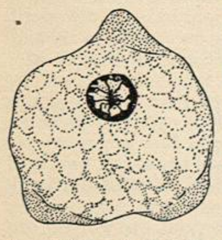

FIG. 5163. — "*Amœba coli*," Stained Preparation. Magnified. (After Doflein.)*

Among the amœboid bodies which one finds in nature and in cultures many are only developmental stages rather than independent organisms, and the same may well be true of some of the parasitic forms. On the other hand, the distinction between such organisms and various structural elements of the human body is often a very difficult task, and some of the purported parasitic species are in fact referable to the misinterpretation of the body cells referred to above.

In the new genus *Entamœba* are included two important human parasites, the life history of which has recently been well elucidated. The other imperfectly known species are left in the old collective genus *Amœba*, but fuller knowledge may result in the transfer of some or all to this same or other new genera according to the facts ascertained regarding the life history of the individual forms.

FIG. 5164.—"*Amœba coli*," in Intestinal Mucus. Magnified. (From Braun, after Lösch.)*

Entamœba coli (Lösch 1875).—(Syn.: *Amœba coli* Lösch 1875; [?] *Amœba dysenteriæ* Councilman and Lafleur 1891; *Entamœba hominis* Casagrandi e Barbagallo 1897; *Entamœba coli* Schaudinn 1903.)

Form oval or pyriform (Fig. 5163); diameter from 0.0075 to 0.05 mm.; nucleus distinct in life, spherical, 0.002, usually 0.003–0.007 mm. in diameter, with heavy nuclear membrane and many small nucleoli. Ectosarc not distinct save in pseudopodia, where it is conspicuous, everywhere less refractive than endoplasm. Pseudopodia rare, usually one or two, broadly lobed and heavy (Fig. 5164). Endosarc finely granular, with one or several non-contractile vacuoles, and many objects ingested as food; such are leucocytes, erythrocytes, eosinophilia, bacteria, starch granules, fæcal particles, epithelial cells, etc. (Fig. 5165). The digestion of erythrocytes is accomplished without excretion of any pigment masses.

Reproduction in the human intestine by simple division and by schizogony, with the formation normally of eight daughter cells. In fission the nucleus undergoes amitotic division, while in schizogony complicated nuclear changes are seen with the elimination of a portion of the chromatic substance. As a preliminary step to encystment all foreign bodies are extruded from the protoplasm, which thus becomes clear and transparent. These cysts, first discovered by Grassi, were carefully studied by Casagrandi and Barbagallo. They constitute the means of transmitting infection, as has been determined experimentally, first by Calandruccio who swallowed such encysted forms and found the developed amœbæ twelve days later in the fæces. The normal seat of this species is the upper region of the colon, and the vegetative forms appear in the fæces only when the latter are semi-fluid by reason of disease or of the administration of medicaments. The cysts which are so characteristic as to be confused with nothing in the fæces are capable of further development only when they contain eight nuclei. Other cysts have been determined experimentally by Schaudinn to be incapable of development, even though they actually constitute the major part (eighty per cent.) of those evacuated. In old dry fæcal matter only the forms with eight nuclei are present, and in the colon of the next host eight small amœbæ are formed by division of the protoplasm and emerge to begin a new infection and a new vegetative period.

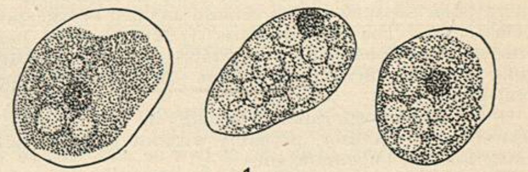

FIG. 5165.—"*Amœba coli*," from Dysenteric Intestine, more or less filled with Erythrocytes; Nucleus also visible. Magnified. (From Doflein after Roemer.)*

This species occurred in East Prussia in fifty per cent. of the cases examined; in Berlin the number found infected was 1:5, and on the Adriatic coast 2:3. The exact distribution of this species has not been further worked out, though the numerous reports lead one to believe that it is a cosmopolitan species.

Grassi was the first to identify the species from the normal human canal, and Schuberg confirmed this by a considerable series of cases. Casagrandi and Barbagallo demonstrated conclusively that it does not possess pathological characteristics, and quite recently Schaudinn in an exceedingly extensive and careful investigation showed the existence of two very similar species, hitherto generally confused, one of which, that under consideration, is a harmless commensal, and the other to be considered next a dangerous parasite. The first lives in the human host in health and is widely distributed; it multiplies excessively in various intestinal disturbances, and is brought to the exterior in fæcal matter by any conditions which produce fluid or semifluid discharges from the canal. It can indeed coexist with the following species, which is pathological in the extreme. The present

* In advance of the appearance of Schaudinn's figures it did not seem advisable to do more than quote the name given in the original from which these cuts were taken.

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species was first carefully studied by Casagrandi and Barbagallo, and is easily recognized from their account. In the majority of cases reported, however, it is difficult to say which form was under examination, although it is probable that in many of them both species were studied and the description contains features characteristic of both. This is the case with the full and valuable account given in Vol. I. of the HANDBOOK. (See *Amœba coli*.) To this admirable review of the subject have been added here only such features as aid in distinguishing the two recently differentiated species.

Entamœba histolytica Schaudinn 1903. (Syn.: [?] *Amœba dysenteriæ* Councilman and Lafleur 1891.)

In many general features like *E. coli*, often occurring together with the latter, and heretofore generally confused with it, yet distinguishable by the following features: Ectoplasm well developed and present as distinct plasma zone, more highly refractive than the endoplasm, viscous in consistence and glass-like in appearance. Nucleus rarely visible in life, almost homogeneous; little refractive, poor in chromatin, usually with a single nucleolus in centre, and with very delicate nuclear membrane, if indeed any is present. Reproduction by division and budding, the latter often multiple, and both following amitotic nuclear division. Cysts with eight daughter cells never found. Resting stages are formed when the fæces grow firmer; the progress of their formation begins by the rejection of chromatin from the nucleus until the entire plasma is filled with chromatin masses, and the nucleus itself degenerates and is absorbed or thrown out. The chromatin masses collect in the peripheral zone of the plasma and come to lie in ectoplasmic hillocks, which develop to free spherules on the surface of the cell. These structures measure only 0.003–0.007 mm. in diameter, and soon acquire a yellowish-brown membrane and a highly refractive semi-opaque appearance. The remainder of the amœba goes to pieces. Schaudinn was able experimentally to evoke a severe dysentery by feeding these spores to cats, and maintains on good grounds that such spores constitute the only means of producing a new infection normally. Injections per anum of the vegetative form alone produced a typical case of the disease, as Jürgens showed first.

While *E. coli* has no power to penetrate the healthy epithelium, *E. histolytica* is able to enter anywhere and force its way through. In this process the amœbæ push the cells apart, and even force them free from the layer. These features were first correctly described by Jürgens, who gave a full and accurate account of this species. His discoveries on the cat have been confirmed by the observations of Schaudinn on man also. The amœbæ were found in sound regions of the mucosa in the glands of Lieberkühn, could be followed on into the submucosa. Undermining of the mucosa and abscess formation follows in later stages of the malady. These investigations demonstrate clearly that *E. histolytica* is a true tissue parasite, like the Myxosporidia, and indeed the most dangerous of all Protozoa yet known, and that it is the cause of ulcerous amœbic enteritis.

Jürgens is the only author who in the opinion of Schaudinn has characterized this species in recognizable form, although the species was probably before many authors, who were unable to differentiate it clearly from the other species, *E. coli*, with which it was certainly associated in some cases reported.

The material from which the pathological species was obtained by Schaudinn came from a limited number of cases of tropical dysentery acquired in Egypt, China, and Siam. The real geographical distribution of the species is thus evidently but imperfectly known.

It is difficult to pass satisfactorily upon the specific character of the forms hitherto observed in the United States, and only two references will be made. The observations of Craig (*Medical News*, March 16th, 1901) seem to have been made on *Entamœba coli* of Schaudinn, in which the former described as "oval spots" the formation of the encysted daughter cells already well known from the work of Casagrandi e Barbagallo. The splendid monograph of Councilman and Lafleur in my opinion deals unmistakably with *E. histolytica* of Schaudinn. The description of the amœbæ is very detailed and precise, and apparently agrees minutely with the characters, such as the form, appearance, and position of the nucleus, advanced by Schaudinn to separate the pathogenic *E. histolytica* from the harmless *E. coli*. The absence of any reference by such careful observers to the formation of cysts, which is easily observed in *E. coli*, must be regarded as confirmative evidence of the presence of the other species. If this opinion with regard to the identity of the forms proves to be correct, the specific name given by Councilman and Lafleur will have to be used in preference to the later form given by Schaudinn and the species will be known as *E. dysenteriæ* (Councilman and Lafleur 1891). Although illustrated by very inadequate figures, the pathological lesions caused by this species are described by these authors with great fulness and care, and anticipate very largely the work of Jürgens, to which Schaudinn accords such well-merited praise.

The following forms included under the generic name *Amœba* are classified thus rather tentatively, as our knowledge of the life history at least is too limited to allow of greater precision. Probably some at least are related to the species just described if not identical with them.

Amœba Miurai Ijima 1898.—Normally isolated individuals (Fig. 5166), adhering in conglomerate-like clusters only when dead or dying. Living specimens, spherical or ellipsoidal, having at one pole a small rounded protuberance or villous knob, which is closely set with fine pseudopodia. Diameter 0.015–0.038 mm. Villous knob papilliform or hemispherical, 0.01 mm. in diameter at base, but capable of entire retraction at times, or the fine pseudopodia may be entirely withdrawn. Nucleus round, oval, or reniform, 0.008–0.015 mm. in diameter, two or three being found in the single cell as often as one. Ectoplasm visible only in villous knob; endoplasm finely granular with one to several conspicuous non-contractile vacuoles and minute oil-like corpuscles.

This form was found by Miura and described by Ijima. It occurred in the serous fluid accumulation of peritoneal and pleural cavities in a female, twenty-six years old, who died from peritonitis and pleuritis endotheliomatosa. The amœbæ were absent at first from the fæces, but made their appearance two days before the patient's death, concomitantly with hemorrhage in the intestine. Living and dead individuals were found together in the freshest serous fluid under rigid precautions against injurious influences, and this is regarded by Ijima as evidence of the abnormal occurrence of the parasite. It has not been reported since then, and is explained by some authors on the basis that the supposed amœbæ were only "exudate cells." Lühe states that this is unquestionably the case.

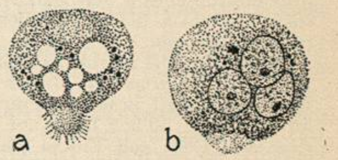

FIG. 5166.—*Amœba Miurai*. *a*, Living; *b*, from specimen preserved in acetic acid. × 500. (After Ijima.)

A considerable number of so-called amœbæ have been reported from various organs in man, and usually pathogenic characteristics have been attributed to them. They are known mostly from single records of their occurrence, and often lack both name and recognizable description. It has been suggested that they are commensals, and of secondary importance. It is equally probable that some at least are occasional or accidental parasites, and devoid of general importance in human pathology. Owing to the general uniformity of structure in this group all but the most careful descriptions are worthless for future study and comparison with other species. A few of the best accounts of these uncertain forms are noted here for reference.

Amœba Kartulisi Doflein 1901.—Diameter 0.03–0.038