

海に漂う小さな生き物の話

松岡數充

水産・環境科学総合研究科付属
環東シナ海環境資源研究センター

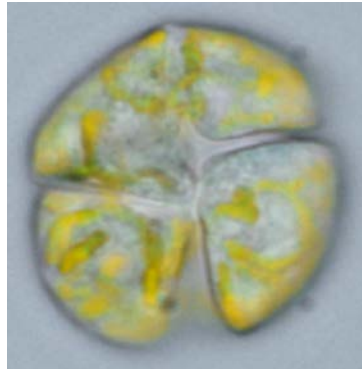
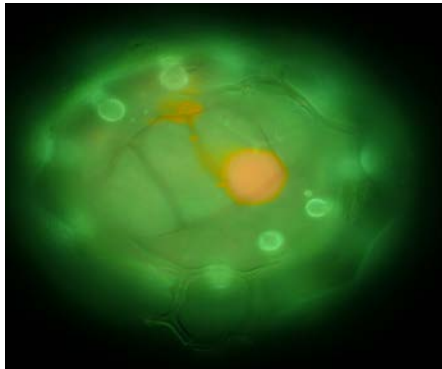
*** 渦鞭毛藻シスト研究の基礎**
—発芽培養実験と分子系統解析—

*** 生きている化石と生物多様性ホットスポット**
—東南アジアの海辺から—

2つの異なったDino

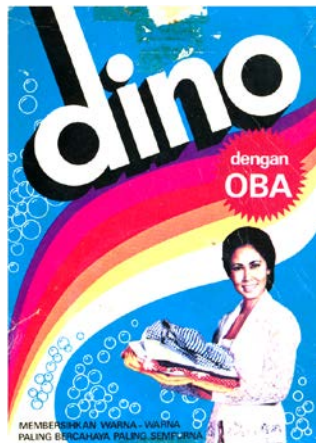
Dinoflagellate

Dino;渦を巻く
回転する



Dinosaurs

Deino;恐ろしい
不思議な



ようこそ、レストラン ディーノへ



フェラーリ・ディーノ・246GTS

イタリアのスポーツカーメーカー・フェラーリが1988年から1994年まで生産したミッドシップの豪華スポーツカー。フェラーリ製のエンジンとエンジン搭載車である。



[恐竜博物館TOP](#)

[Menu](#)

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渦鞭毛藻とはどんな生き物か

◆アピコンプレクサ類の一員

(マラリア原虫, 繊毛虫, 渦鞭毛藻類)

細胞外皮(渦鞭毛藻の場合はアンフィエスマと呼ぶ)

◆現生種; 238属2294種 (Gómez 2012)

◆浮遊性, 底棲性, 付着性, 寄生性

◆海産, 汽水産, 淡水産

◆独立栄養性, 混合栄養性, 従属栄養性

◆シスト形成種; 約200種 (Matsuoka & Fukuyo 2000)

◎有害(赤潮形成)・有毒性(麻痺性貝毒原因種)

◎鎧板を持つ有殻と持たない無殻

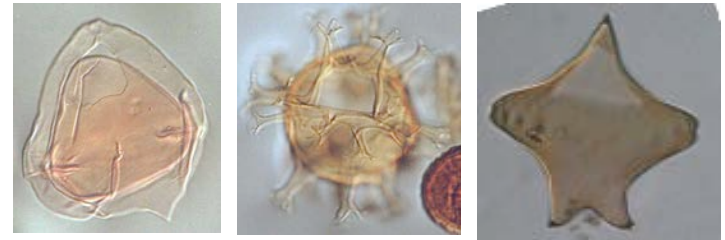
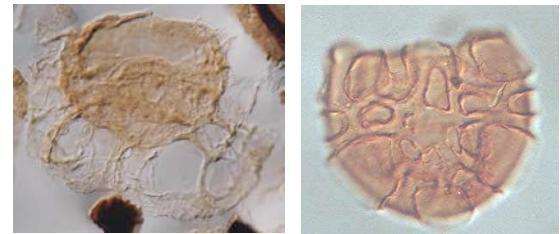
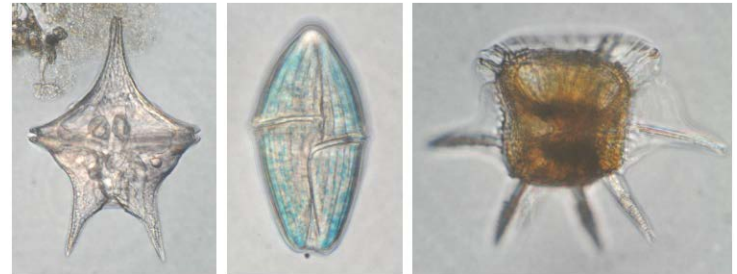
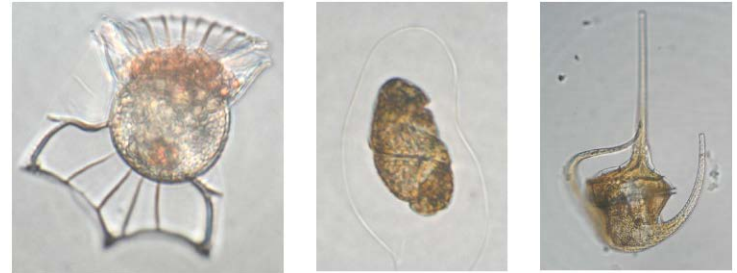
◆化石種;

627属4070種 (Fensome & Williams 2004)

最古の化石;

三畳紀から出現,

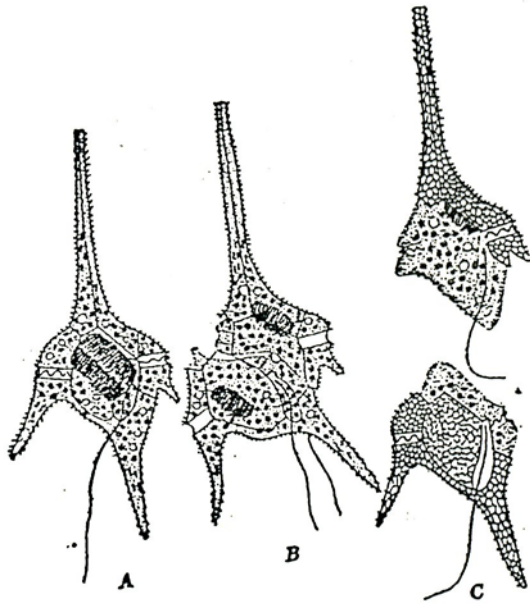
ジュラ紀に多様性増加



Müller, O. F. (1773). *Vermium terrestrium et fluviatilium, seu animalium infusoriorum, helminthicorum et testaceorum, non marinorum, succincta historia. Vol. 1 pp. [1-33], 1-135.*



Othone Friderico Müller



Bursaria hirundinella
= *Ceratium hirundinella*

ZOOLOGIÆ DANICÆ
PRODROMUS,

SEU

ANIMALIUM

DANIÆ ET NORVEGIÆ INDIGENARUM

CHARACTERES, NOMINA,

ET

SYNONYMA IMPRIMIS POPULARIUM.

AUCTORE

OTHONE FRIDERICO MÜLLER,

REGI DANICÆ A CONSILII STATUS, ACAD. SCIENT. N. CURIOS.
HOLMENS. ET BOICÆ, HAVNIENS. NORV. BEROLINENS. ALIA-
RUMQUE SOCIET. LITER. SODALI, ACAD. PARIS. CORRESP.



IMPENSIS AUCTORIS.

HAVNIÆ,
TYPIS HALLAGERIIS.

CID DCC LXXXVI.

1776.

206 VERM: INFUS: BURS: CERC: TRICH:

2479. BURSARIA *truncatella*, ventricosa, apice truncata.
*Mofe-Pungen. V. 54. * +*

2480. B. *Hirundinella*, excavata, mucronata. *Strut-Pungen.*
*V. 55. * +*

* Teretes.

2481. CERCARIA *Gyrinus*, rotundata, cauda acuminata;
*Frö-Unge-Haleren. V. 56. AFB. **

2482. C. *Catellus*, tripartita, cauda bifida. *Killing-Haleren.*
*V. 57. * +*

2483. C. *Podura*, cylindracea, postice acuminata, subfissa.
*Loppe-Haleren. V. 58. * +*

2484. C. *Lupus*, cylindrica, elongata, torosa; cauda spinis
duabus. *Ulv-Haleren. V. 59. * +*

2485. C. *Lemma*, mutabilis, cauda annulata. *Ande-Mad-*
*Haleren. V. 60. * +*

** Depressa.

2486. C. *Cyclidium* ovalis, postice submarginata; cauda ex-
fertili. *Rund-Haleren. V. 61. * +*

2487. C. *Tenax* membranacea, antice crassiuscula, truncata,
cauda triplo brevior. *Sei-Haleren. V. 62. * +*

2488. C. *Pleuronectes* orbicularis, cauda unifeta. *Flönder-*
*Haleren. V. 63. * +*

2489. C. *Tripos* subtriangularis, brachiis deflexis. *Tre-Fod-*
*Haleren. In aqua marina. * +*

* Caudata.

2490. TRICHODA *Clava*, clavata fronte crinita; cauda re-
flexili. *Kolle-Spilleren. V. 64. * +*

2491. T. *Pupa*, cucullata, fronte crinita, cauda inflexa. *Puppe-*
*Spilleren. V. 65. * +*

2492.

フリント中の渦鞭毛藻化石



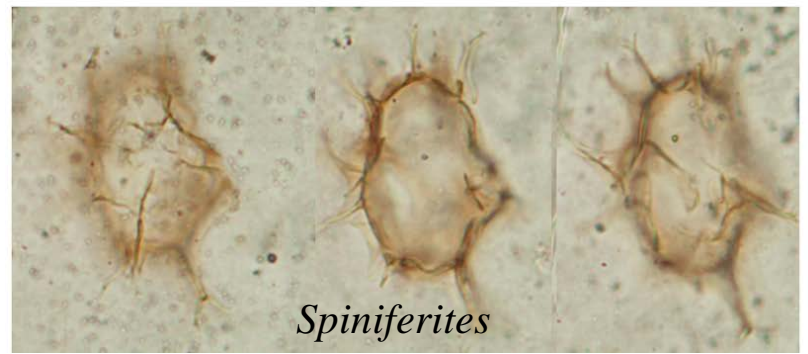
1836 Ehrenberg, C.G



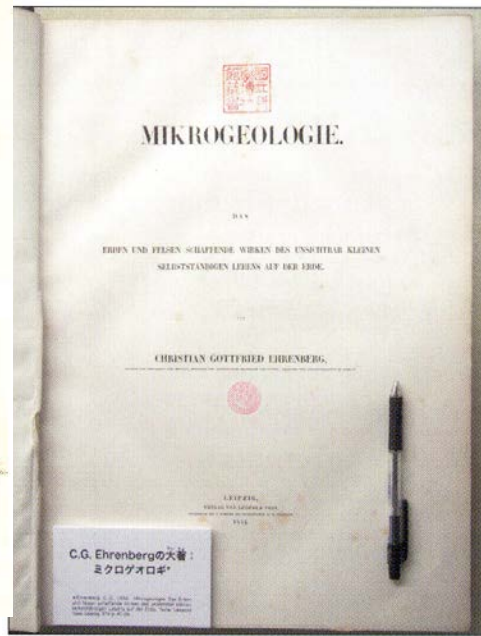
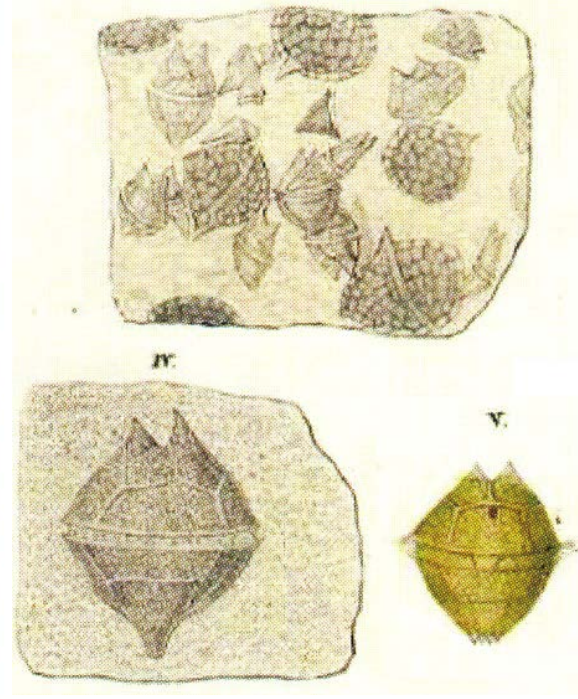
Hystrichosphaeropsis



Ceratiopsis



Spiniferites

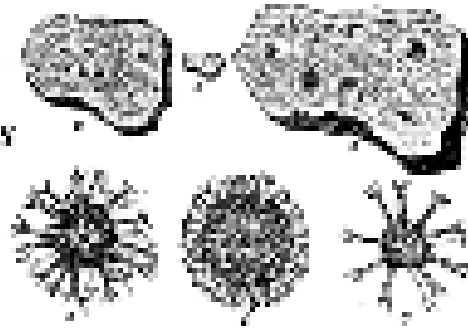


渦鞭毛藻シストと恐竜の歯

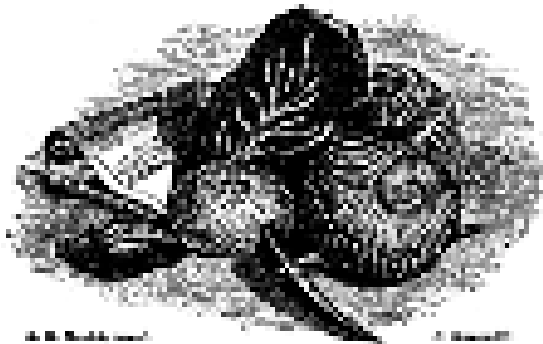
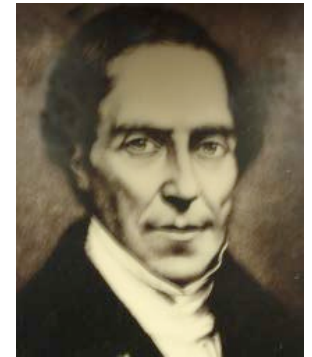


THE
METHODS OF CREATION;
OR,
FIRST LESSONS IN GEOLOGY,
AS TAUGHT BY
OSWALD REYNOLDS
IN
GEOLOGICAL MUSEUM, LONDON.
BY
GEOFFREY HENRI MANTELL, ESQ., F.R.S.

Genus
Spiniferites



Mantell, G. A

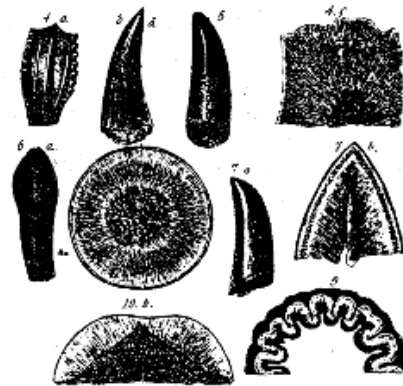


LION. 53. XANTHIDIA IN FLINT.
Fig. 1.—A thin translucent chip of flint: nat.
2.—The same magnified, and viewed by transmitted light; showing a group of five Xanthidia.
3.—The same, more highly magnified.
4.—XANTHIDIUM RAMOSUM; one of the animalcules seen in Fig. 3, very highly magnified.
5.—XANTHIDIUM RINGINALDI; one of the same group.
6.—A variety of XANTHIDIUM RAMOSUM; another of the same cluster of Xanthidia.

BY
GEOFFREY HENRI MANTELL, ESQ., F.R.S.
WITH
ILLUSTRATIONS BY
GEOFFREY HENRI MANTELL, ESQ., F.R.S.
AND
OSWALD REYNOLDS, ESQ., F.R.S.
LONDON:
PRINTED BY
JOHN WOODHEAD, ST. MARTIN'S LANE.



Iguanodon



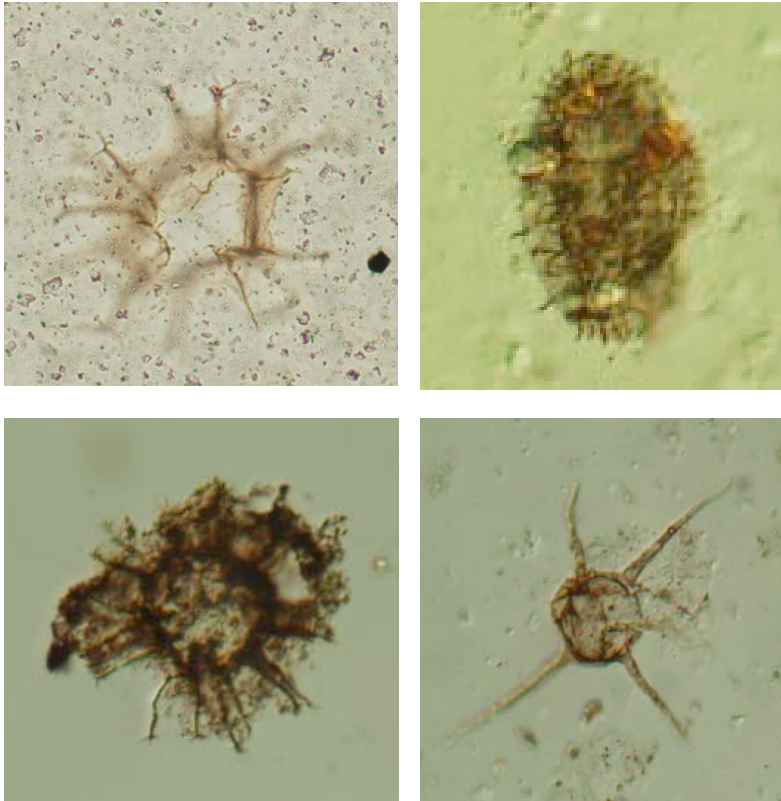
From *Illustrations of the Dinosaurians*, 1830.

Megarosaurus



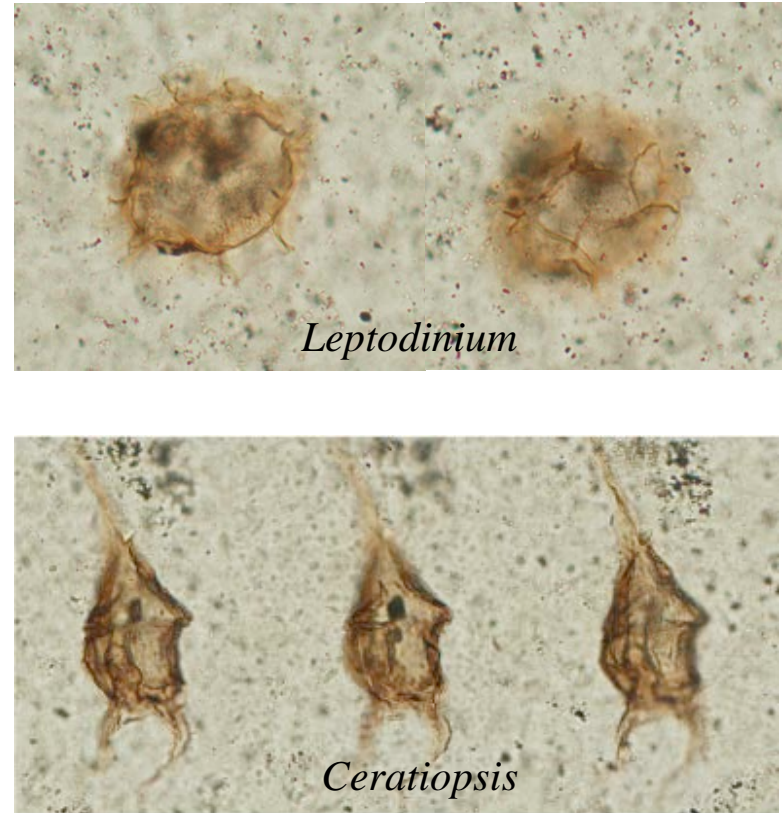
謎の微化石 ; hystrichosphere

Hystrichosphere



球形で表面に多数の突起物を備えた所属不明の有機質微化石

Dinoflagellata



鎧板に類似した構造やペリディニオイド型の外形

しかし後にhystrichosphereの一部は渦鞭毛藻シストであることが判明

シストー遊泳細胞関係解明以前の 生活史に関する研究

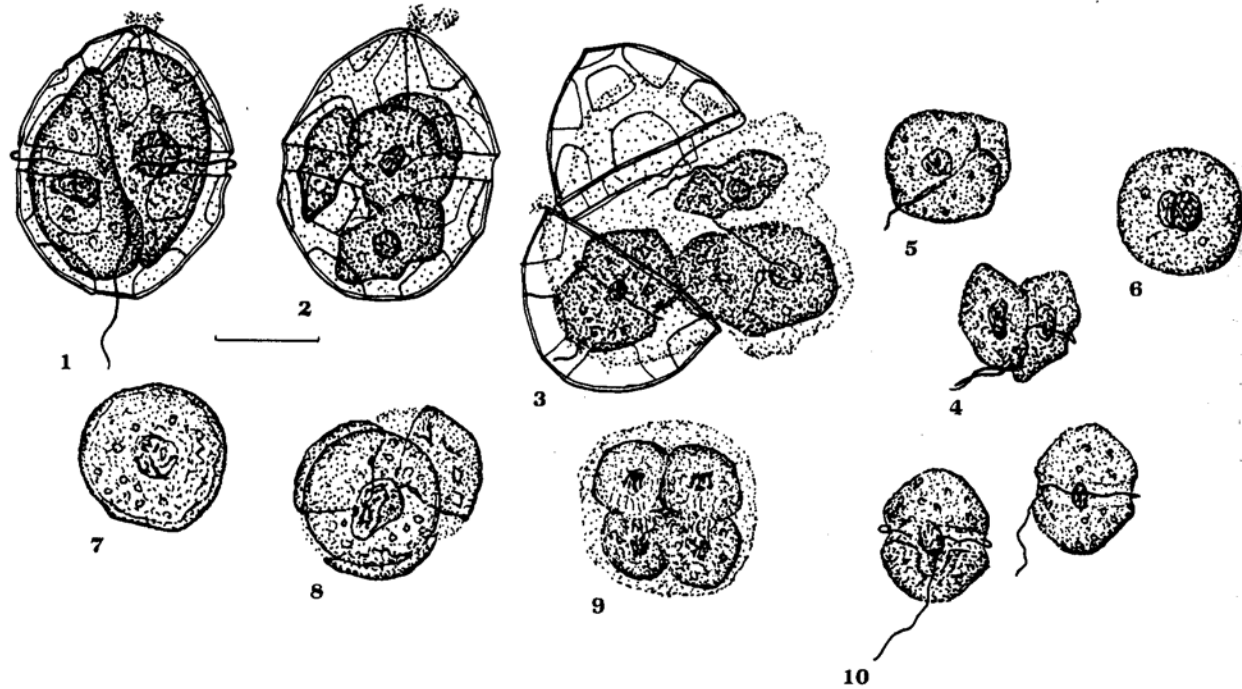


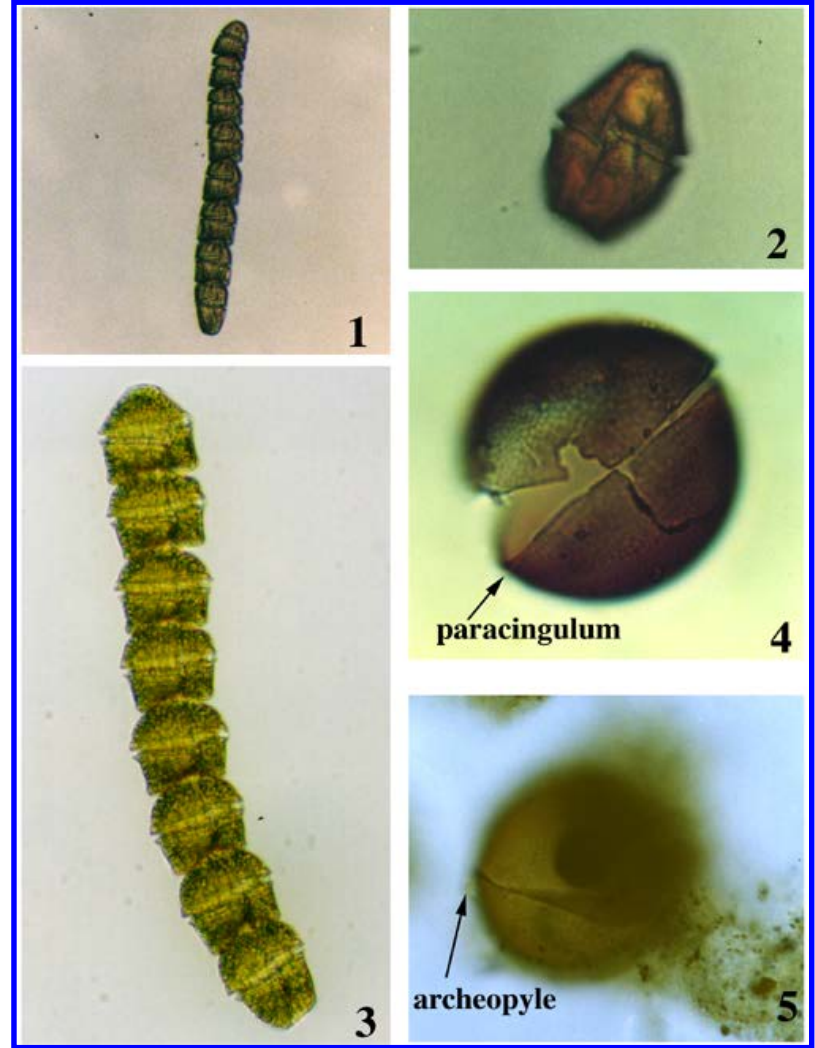
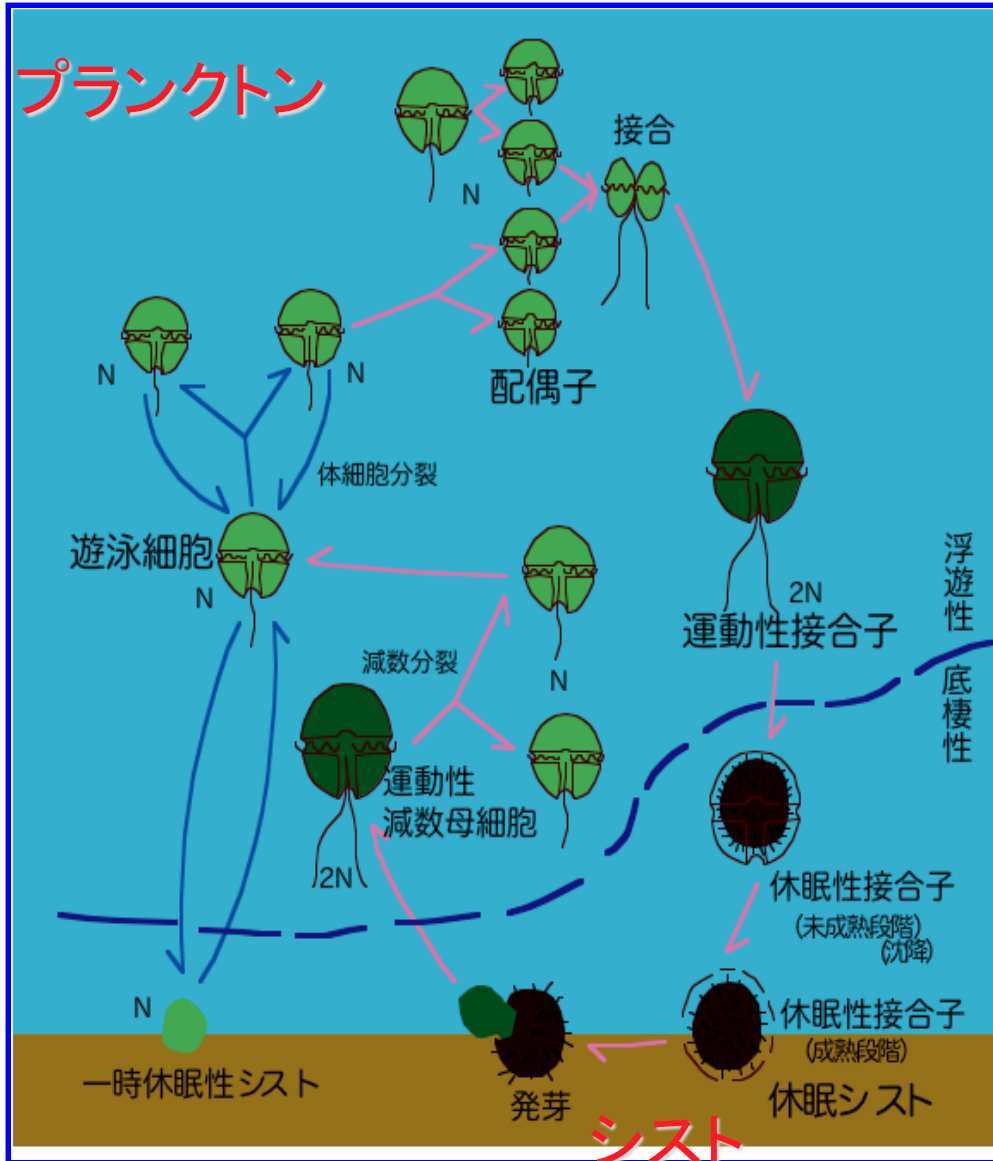
Figure 4.81

Peridiniopsis tubiniensiforme. Sexual reproduction and encystment in a freshwater dinoflagellate. Bar = 15 μm . 1,2. Development of gametes within parent theca. 3. Release of gametes. 4,5. Gametes joining in pairs to form zygote. 6,7. Resting zygote cyst. 8. Germination, resulting in disruption of cyst. 9,10. Production of four daughter cells (probable result of meiosis) that become new motile cells. Redrawn from Diwald, 1938.

Diwald 1937

シストは単純な形態でしか描かれていない

化石渦鞭毛藻はシスト（休眠細胞）だった



Gymnodinium catenatum

すべては発芽実験から始まった



William R. Evitt

IV-IPC at Calgary, 1984

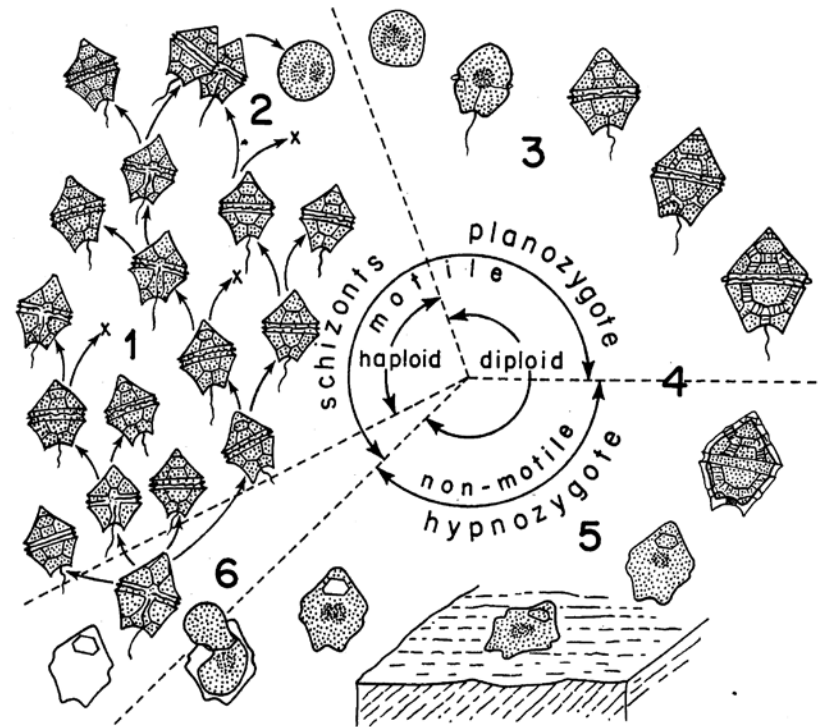


Figure 1.3 - SCHEMATIC LIFE CYCLE OF CYST-PRODUCING DINOFLAGELLATE
(Numbers refer to steps described in text; x's in Step 2 represent the unfigured second products of binary fission.)

Wall, D. & Dale, B. と彼らが明らかにした 渦鞭毛藻の生活史



Barrie Dale & David Wall At Dino V, Utrecht, 1993

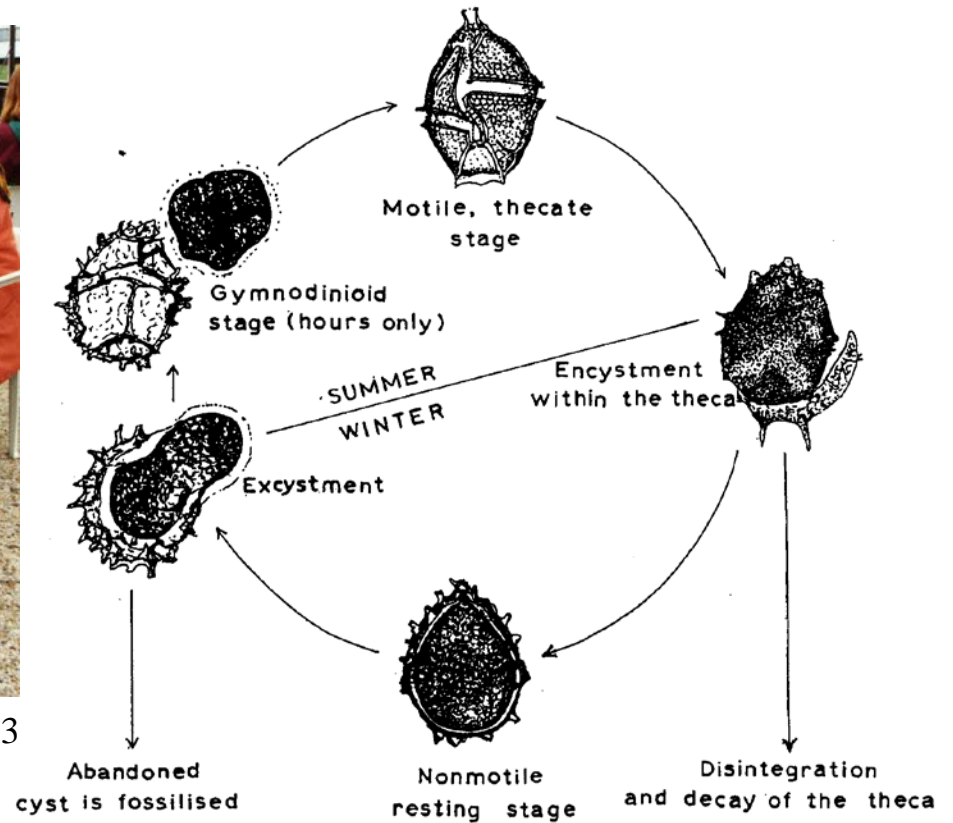
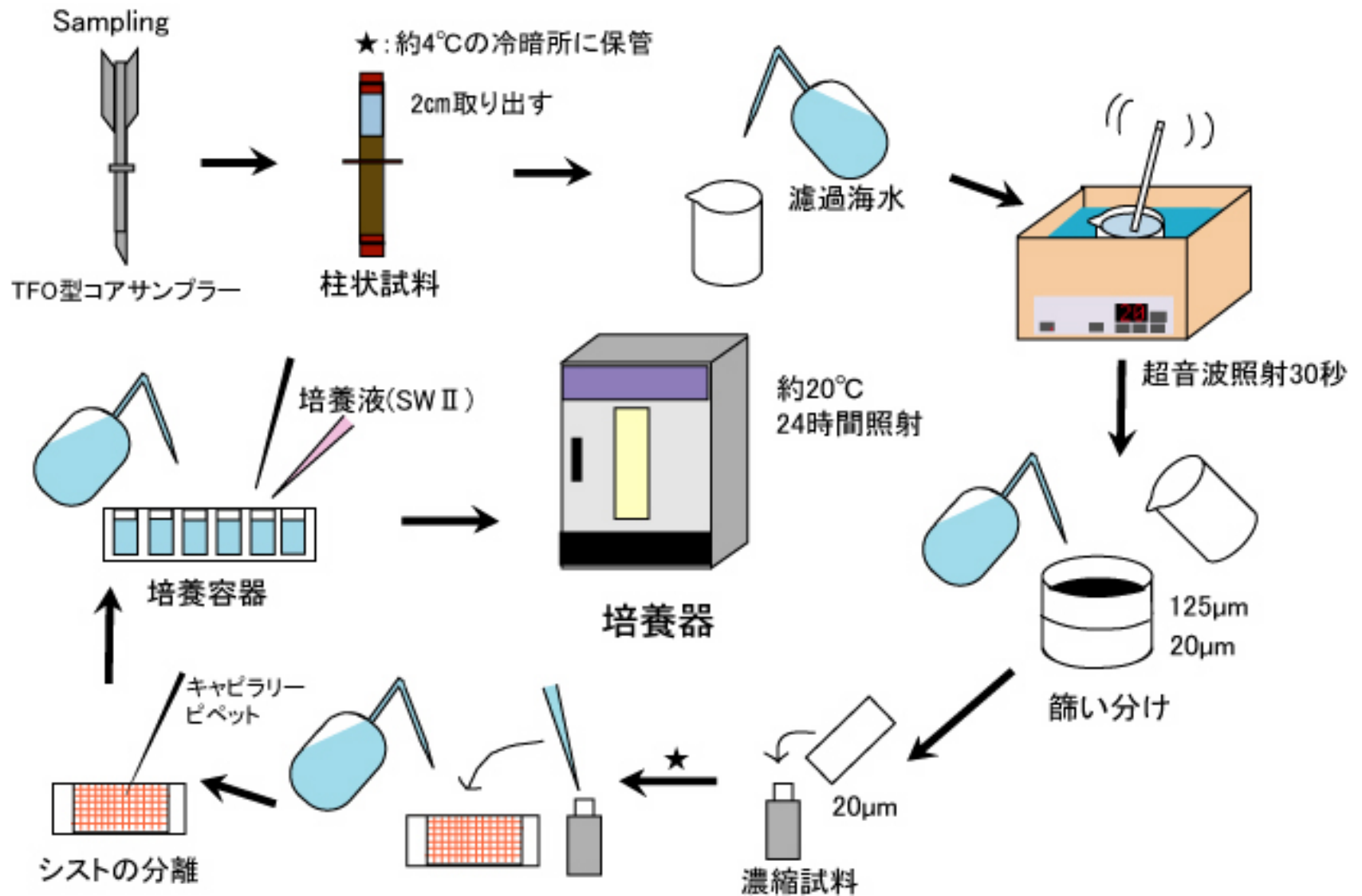
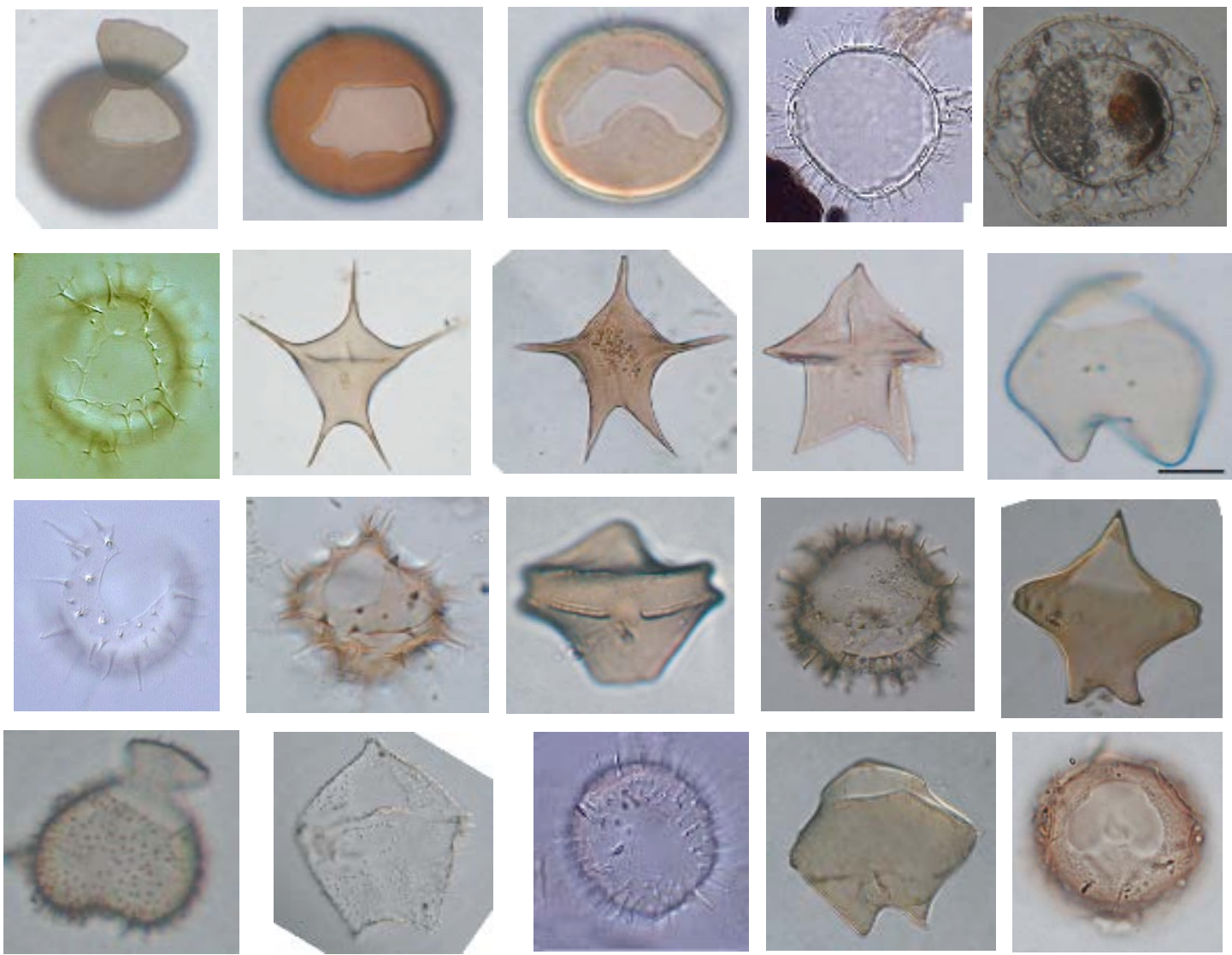


FIG. 17. Theca-cyst cycle of the living marine dinoflagellate *Gonyaulax digitalis* (Pouchet) Kofoid. The resting cyst is identical with the fossil species *Spiniferites bentori* (Rossignol) Sarjeant. Redrawn after Wall and Dale, 1968.

発芽実験



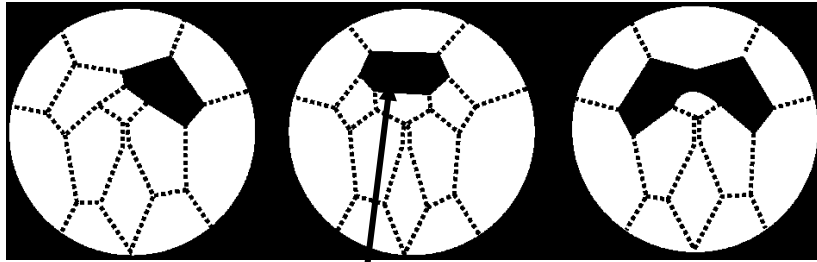
発芽実験によって確認された プロトペリディニウム類とゴニオラックス類のシスト



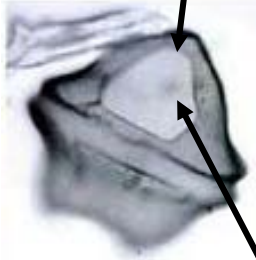
化石渦鞭毛藻の認定



鎧板構造の反映

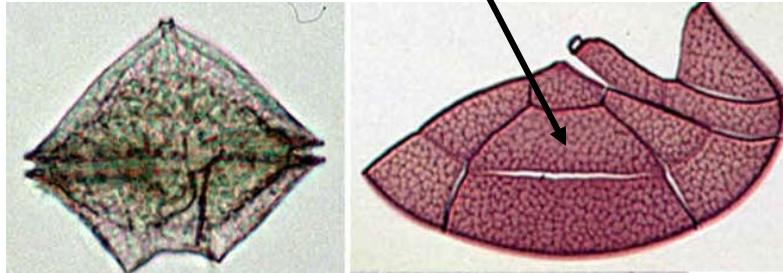


シスト



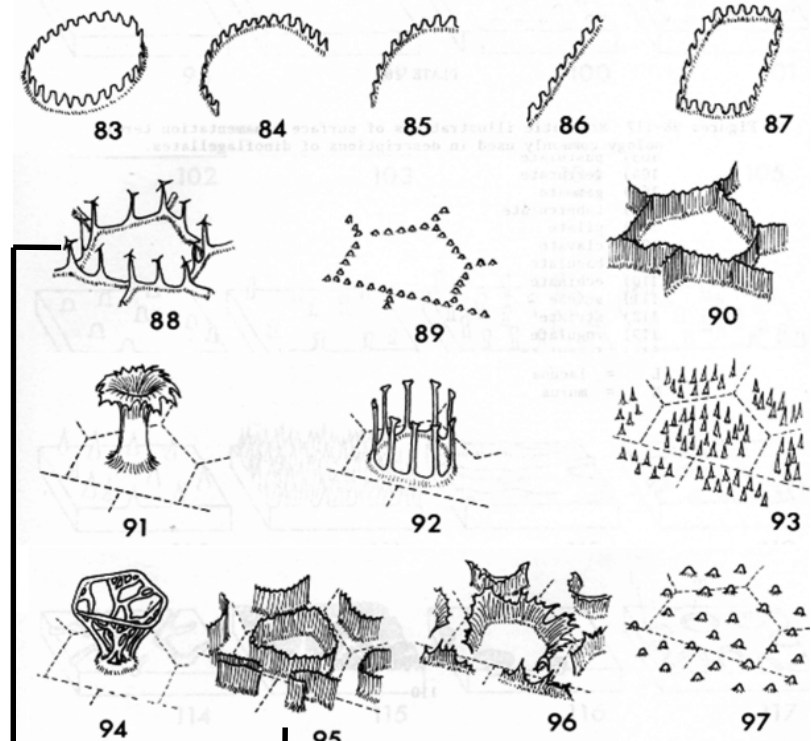
Protoperidinium leonis

鎧板に相当する
発芽孔



栄養細胞

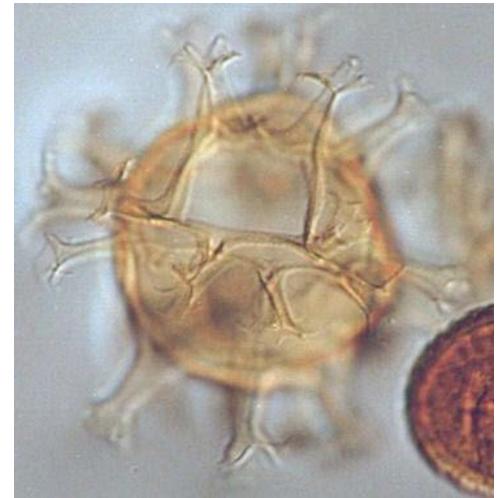
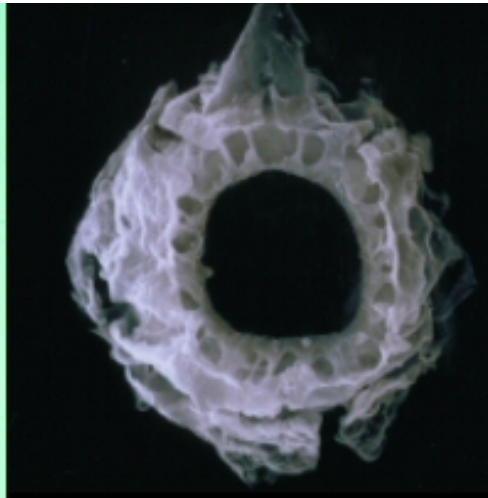
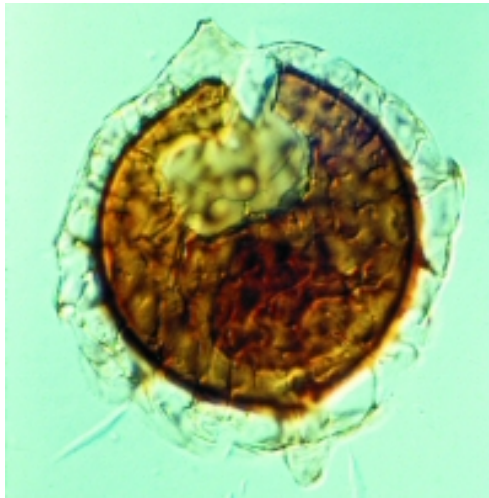
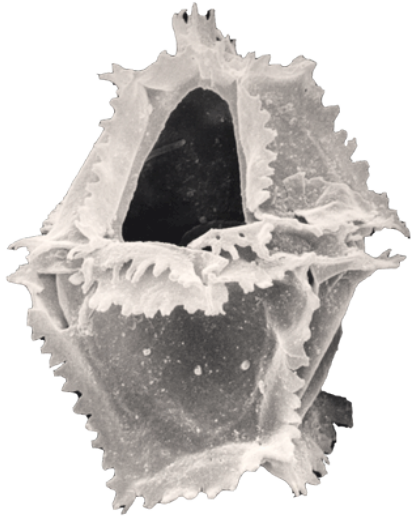
鎧板に相当する
発芽孔



偽鎧板や偽縫合線

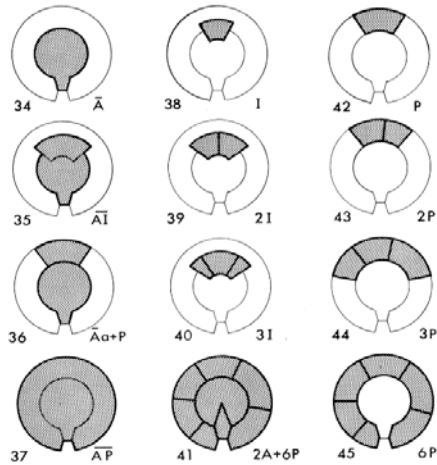


化石渦鞭毛藻の認定は殻構造(発芽孔・鎧板)を反映した形態



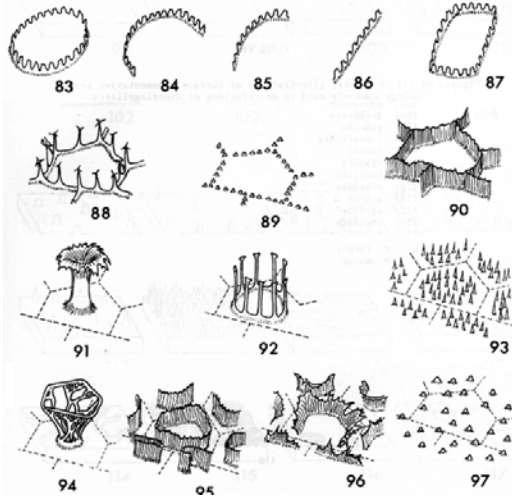
化石渦鞭毛藻の記載用語

発芽孔



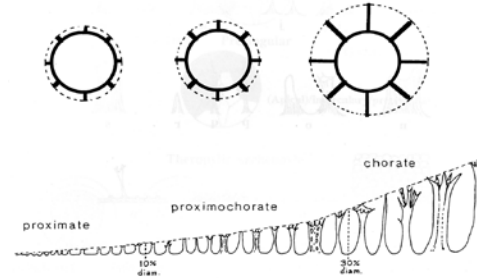
Saphopylic and theropylic type

偽鎧板



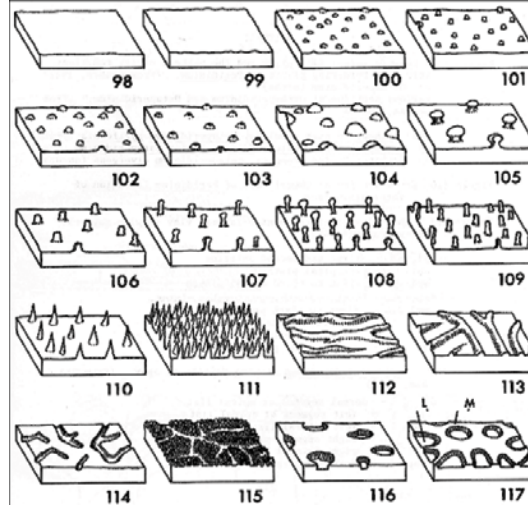
Paraplate and parasuture

シストの大きさ



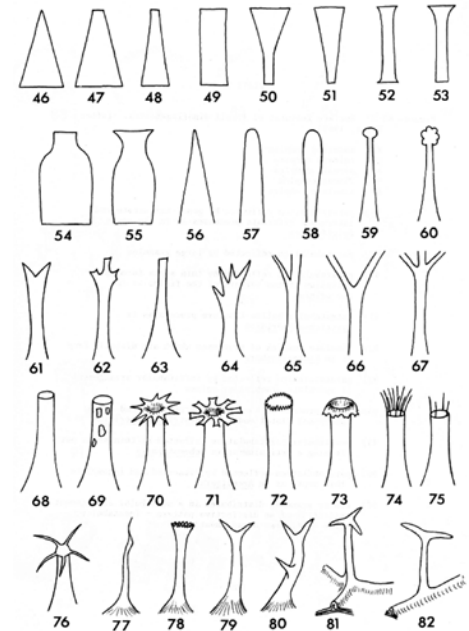
Chorate
Proximochorate
Proximate

シスト壁の装飾



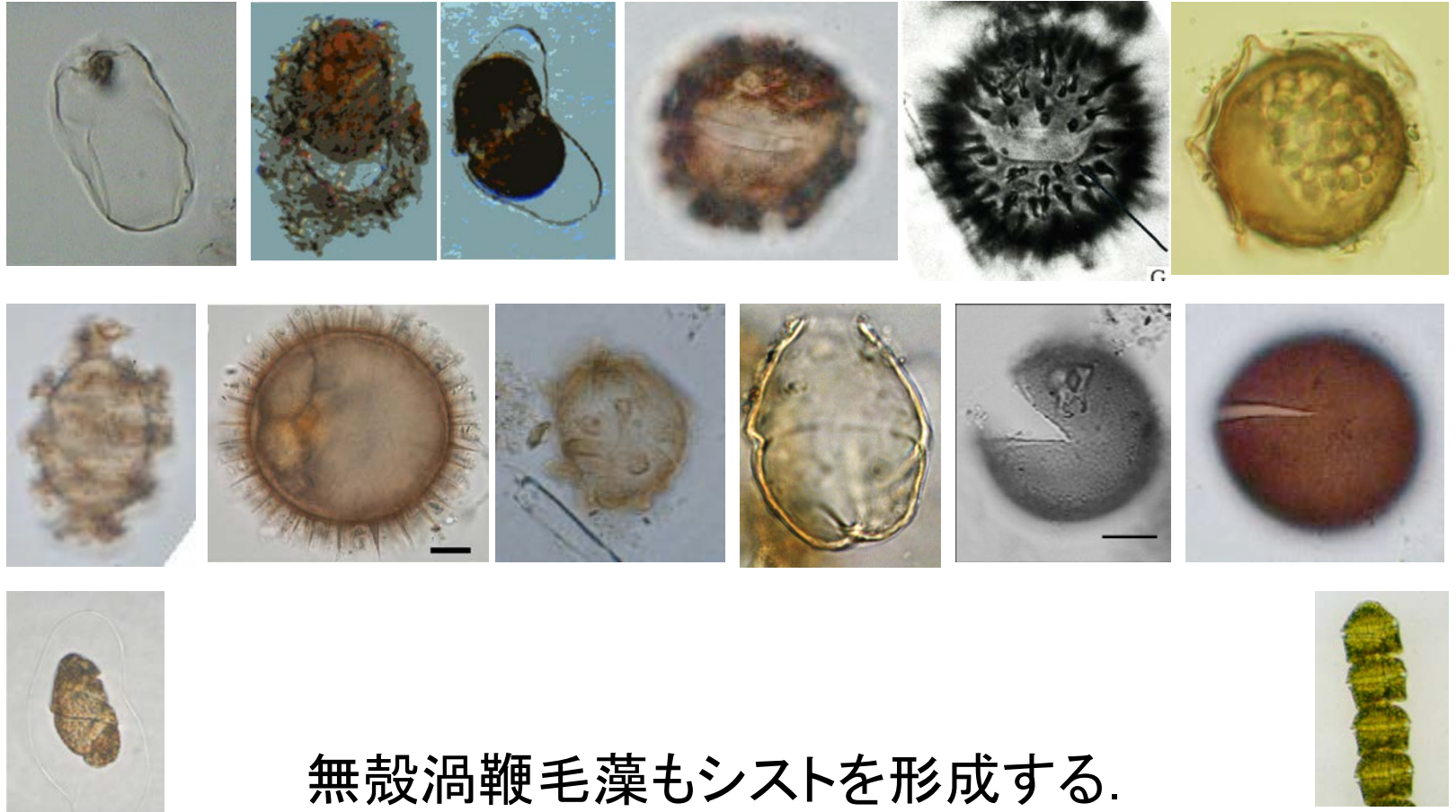
Morphology of cyst wall

突起物の形態



Morphology of processes

鎧板構造が明瞭でない有機質微化石はアクリタークか しかし



無殻渦鞭毛藻もシストを形成する。
それらのシストは殻構造を反映していないのでは？

明瞭でない発芽孔が現生の無殻類，有殻種シスト類にも存在

渦鞭毛藻シストの新たな概念

Cryptopylic archeopyle

Review of Palaeobotany and Palynology, 44(3-4), pp.217-231; 1985

ARCHEOPYLE STRUCTURE IN MODERN GYMNODINIALEAN DINOFLAGELLATE CYSTS

KAZUMI MATSUOKA

Department of Geology, Faculty of Liberal Arts, Nagasaki University, Nagasaki 852 (Japan)

Description of new archeopyle types

(1) Chasmic archeopyle (Fig.1D, E)

Derivation of name: Greek χάσμα = chasm.

Definition: The opening is a linear to slightly curved rupture without operculum, and mainly formed at the median zone on the cyst. Length of rupture is various and ranges from one-tenth to half of the cyst diameter. Rupture line is mostly smooth, but rarely slightly zigzag.

Remarks: An operculum is not produced, the protoplasm being released through a simple rupture. If this archeopyle is small, its optical cross-section shows a shallow V-shape. In other cases, the rupture may be well developed, with the cyst body almost being cut into two hemispheres.

The cysts belonging to two gymnodinialean dinoflagellates have this archeopyle type: *Polykrikos hartmannii* Zimmermann (Fig.1D) and *Cocholodinium* sp. (Fig.1E). Openings similar to this type are also observed in such early Paleozoic acritarchs as the genera *Michrhystridium*, *Orthosphaeridium*, and *Unellium*.

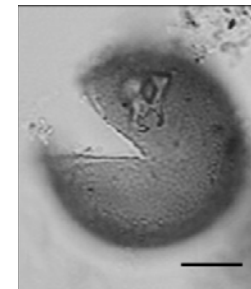
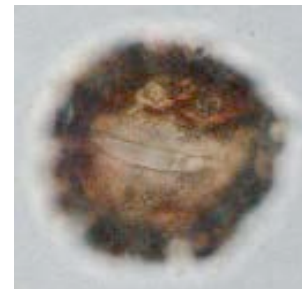
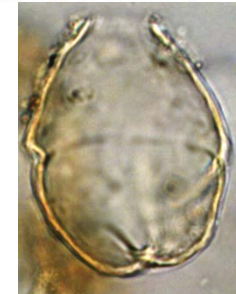
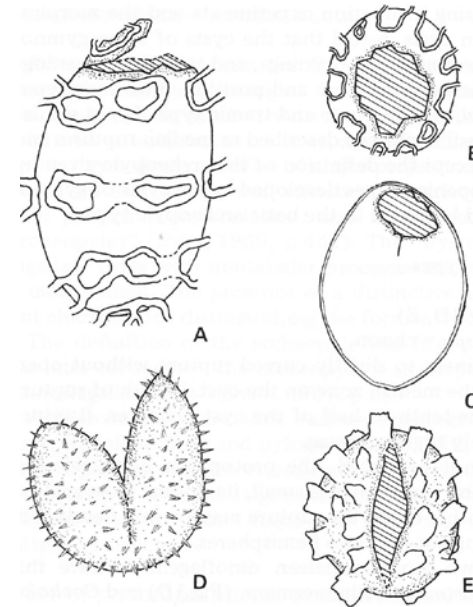
(2) Tremic archeopyle (Fig.1A-C)

Derivation of name: Greek τρήμα = hole.

Definition: The opening is circular to nearly circular in shape, sometimes with a slightly zigzag margin, and is usually formed in the polar region, i.e. probably the apical area, but rarely elsewhere. Margin of the opening is thickened in some cases.

Remarks: This opening type, formed in the cyst of *Polykrikos schwartzii* Bütschli, has been recognized as an apical archeopyle by Harland (1977, 1981) and Reid (1978). The definition of an apical archeopyle given by Evitt (1967, p.16) is as follows: "The apical archeopyle includes the apex of the cyst and does not extend to the cingulum, it usually corresponds to apical thecal plates alone, but minor intercalary plates may be represented in some examples".

The opening observed in the cyst of *Polykrikos schwartzii* is situated at the polar region, probably the apical area, and its margin shows a slightly zigzag line. The cyst, however, lacks any such paraplates as seen in many cysts of peridinialean dinoflagellates, and therefore the zigzag margin does not seem to be identical with either principal or accessory archeopyle sutures.



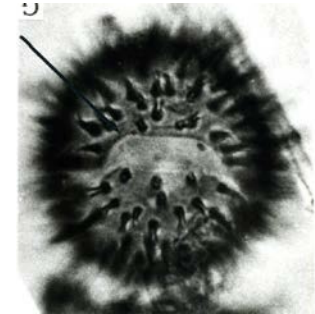
Theropylic archeopyle

Review of Palaeobotany and Palynology, 44(3-4), pp.217-231; 1985

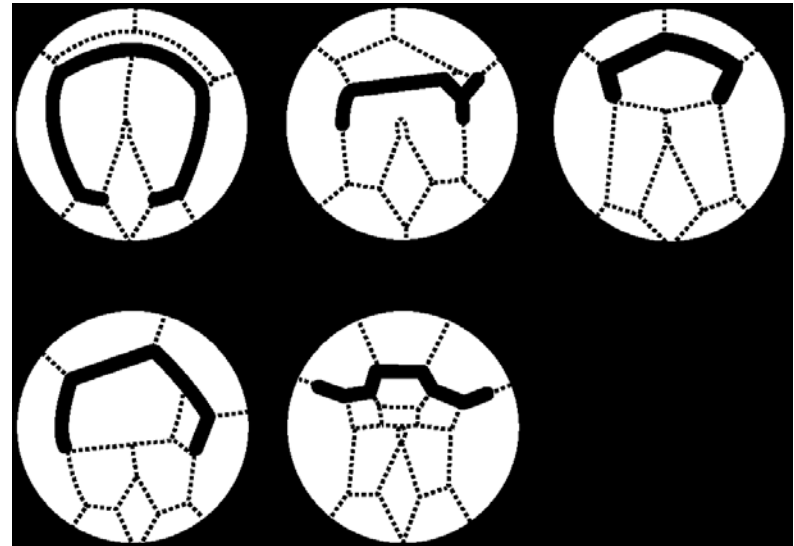
CYST-THECA RELATIONSHIPS IN THE DIPLOPSALID GROUP (PERIDINIALES, DINOPHYCEAE)

KAZUMI MATSUOKA

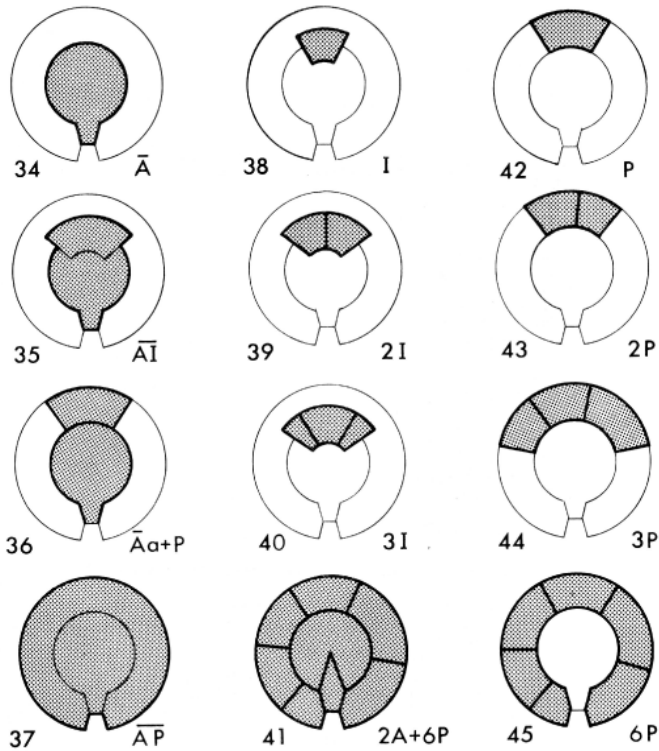
Department of Geology, Faculty of Liberal Arts, Nagasaki University, 1-14, Bunkyo-machi, Nagasaki, 852 (Japan)



The opercular type of the transverse archeopyle defined by Bujak and Davies (1983) is basically identical to the adnate type of Evitt (1985). However, Evitt (1985) suggested no term for a cyst or corresponding archeopyle that is characterized by opercula that differ in their degree of attachment. Therefore, I suggest that cysts or archeopyles having adnate opercula will be described as "theropylic", (Greek *thairos* + *pyle*; hinge of a door + gate) and those that have free opercula (which may sometimes be adherent) will be called "saphopylic" (Greek *saphes* + *pyle*; distinct + gate). As far as we know, the theropylic archeopyle has been observed in cysts of the diplopsalid group (this paper), *Scrippsiella trochoidea* by Wall and Dale (1968), *Ensiculifera* sp. (personal observation) and a few freshwater *Peridinium* species; *P. limbatum* and *P. wisconsinense* (Evitt and Wall, 1968; Wall and Dale, 1968).



多様な発芽孔

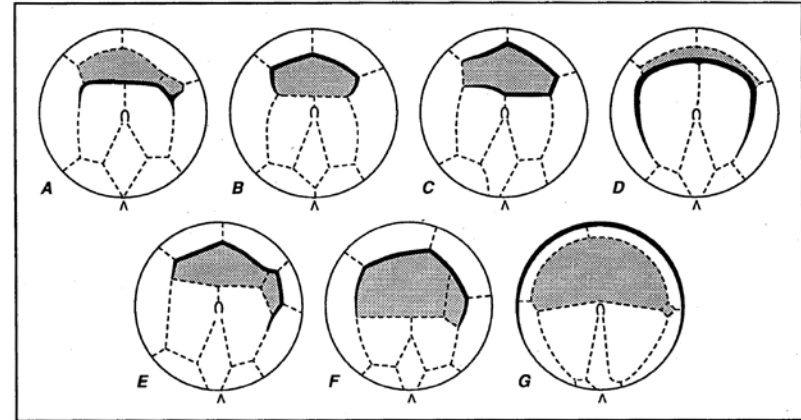


Saphopylic archeopyle (前挿間板などの鎧板に相当)

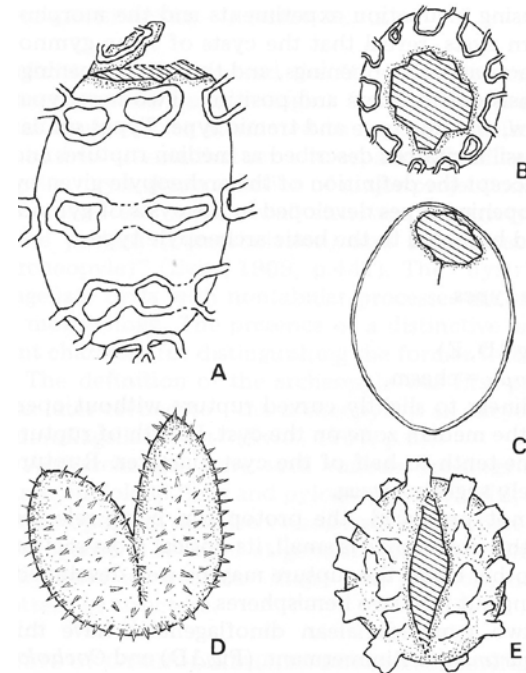
Cryptopylic archeopyle (鎧板に相当しない)

Tremic (A, B, C)
Chasmic (D, E)

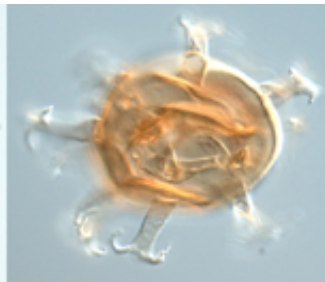
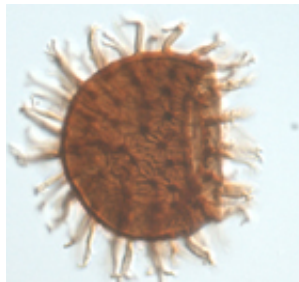
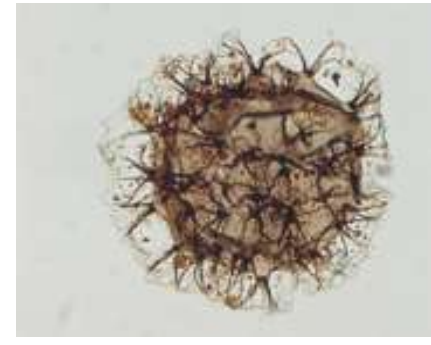
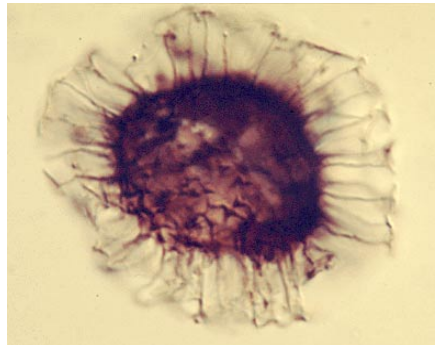
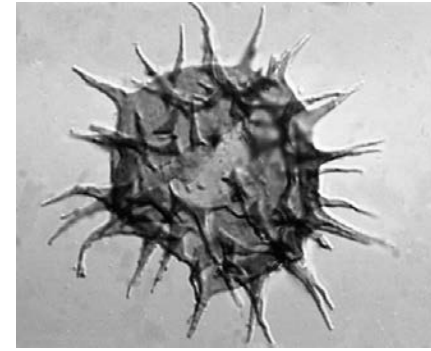
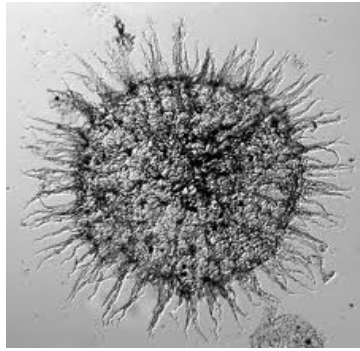
Theropylic archeopyle (鎧板の縫合部に相当)



TEXT-FIGURE 145
Family Congruentiidae (subfamily Diplopsalioideae). Sutural or "theropylic" archeopyles in cysts of selected genera. A. *Diplopetia parva* in apical view. B. *Diplopsalis lebouriae* in apical view. C. *Diplopsalis lenticula* (according to Wall and Dale 1968b, text-fig. 7) in apical view. D. *Diplopsalis lenticula* (according to Matsuoka 1988) in apical view. E. *Diplopsalopsis orbicularis* in apical view. F. *Gotoius abei* in apical view. G. *Zygabikodinium lenticulatum* in apical view. KEY: Intercalary plates are shaded to facilitate orientation. Inverted "V" indicates position of flagellar insertion. Variably heavy black lines indicate archeopyle (or excystment) sutures. SOURCE: adapted from Matsuoka (1988, text-figs. 2B,3B,3D,4B,5B,7B and 8B).



Hystrichosphereとされた休眠孢子群には 渦鞭毛藻とアクリタークが含まれる



鎧板に対応しない開裂や発芽孔のない有機質微化石

アクリタークとは何者か？

生物多様性(種多様性)と渦鞭毛藻シスト

シスト研究者はスプリッターか

Gonyaulax



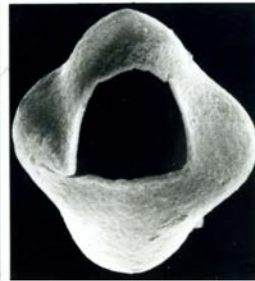
一括主義者
(ランパー; lumper)



Spiniferites



Lingulodinium



Tectatodinium

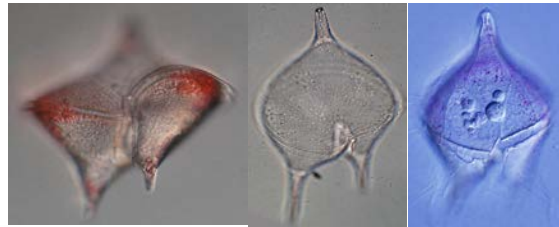


Impagidinium

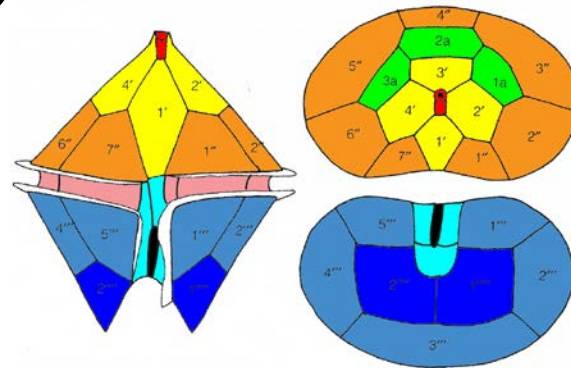
細分主義者
(スプリッター; splitter)

Protoperidinium科

* 有殻渦鞭毛藻類で
最も大きなグループ(250種以上)



鎧板配列



Apical pore plate Po
Apical plate ' ,
Anterior Intercalary plate a
Precingular plate ''
Cingular plate c
Sulcal plate s
Postcingular plate '''
Antapical plate ''''

* 従属栄養性

食胞膜を用いて捕食



鎧板配列様式:

Po, X, 4', 3a, 7'', 3c+t, 6s, 5''', 2''''

Protoperidinium 亜属: 前挿間板 3枚 (3a)

例外あり:

Minusculum 亜属; 前帯板6枚(6'')

Testeria 亜属; 前挿間板 1枚 (1a)

Archeaperidinium 亜属: 前挿間板 2枚(2a)

鎧板配列(形態)に基づく *Protoperidinium* 属の分類

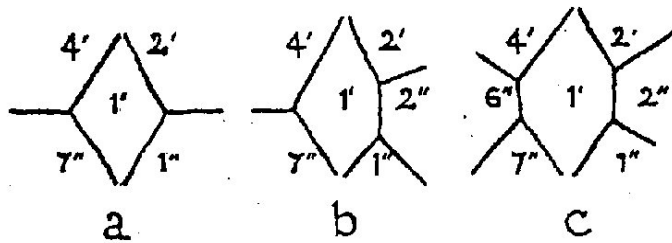


Diagram showing arrangement of first apical plate in

a. Orthoperidinium. b. Metaperidinium. c. Paraperidinium.

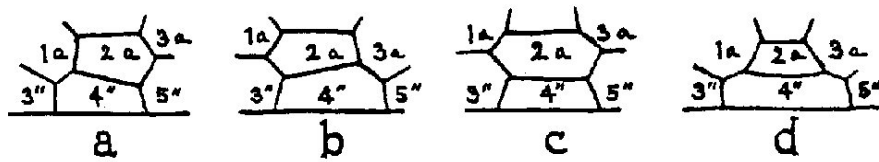


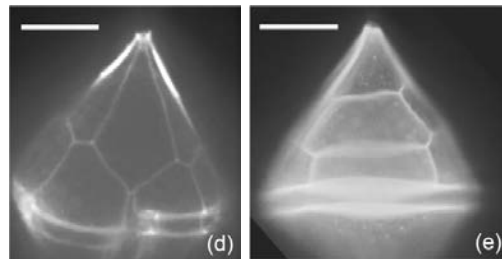
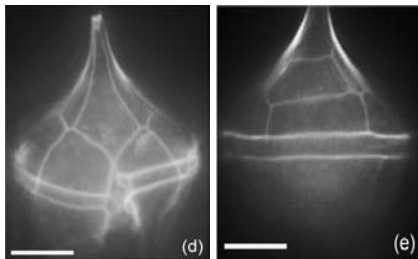
Diagram showing arrangement of the second anterior intercalary plate in the sections of Orthoperidinium and Metaperidinium.

a and b. Orthoperidinium *Tabulata*, Metaperidinium *Pyriformia*.

c. Orthoperidinium *Conica*, Metaperidinium *Paraperidinium*.

d. Orthoperidinium *Oceanica*, Metaperidinium *Divergens* and *Humilia*.

Lebour 1925



Genus *Protoperidinium*

Subgenus *Archaeoperidinium*

Section *Avellana*

Section *Excentrica*

Subgenus *Minuscula*

Subgenus *Testeria*

Subgenus *Protoperidinium*

Group *Orthoperidinium*

Section *Oceanica*

Section *Tabulata*

Section *Conica*

Group *Metaperidinium*

Section *Divergentina*

Section *Humilia*

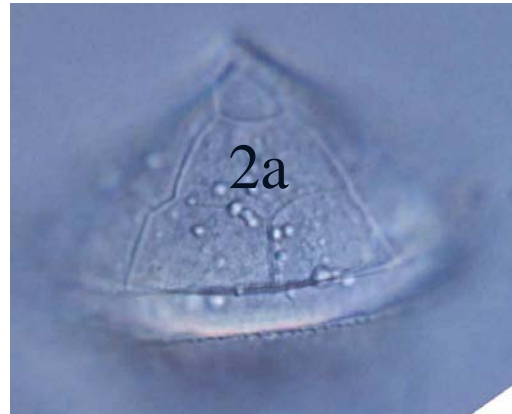
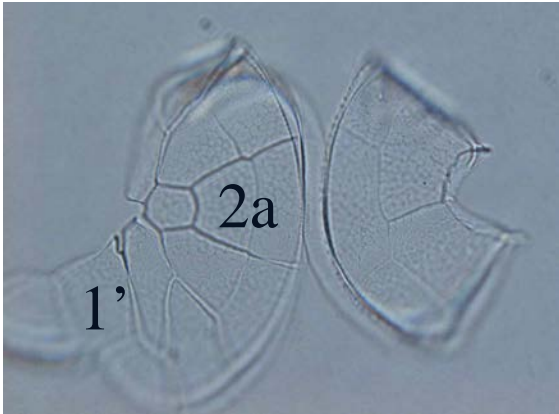
Section *Pyriformia*

Group *Paraperidinium*

**including the type species;
*Protop. pellucidum***

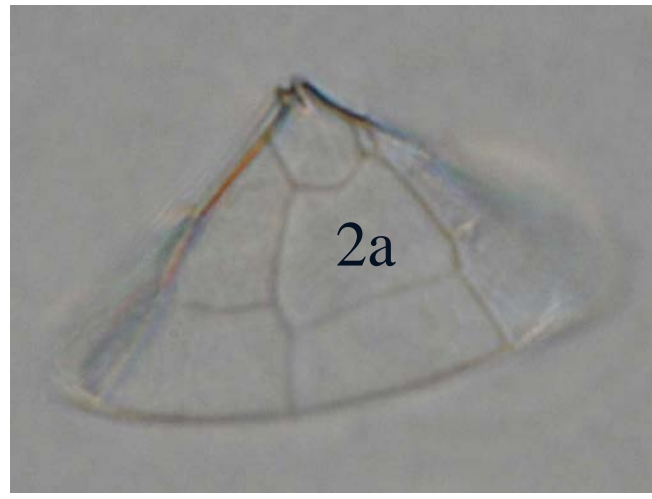
by Jörgensen 1912

形態形質に基づくシストー遊泳細胞 対応関係確立の限界



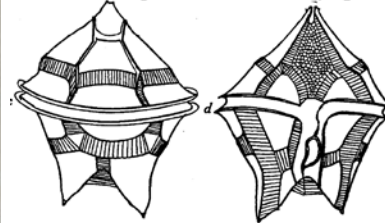
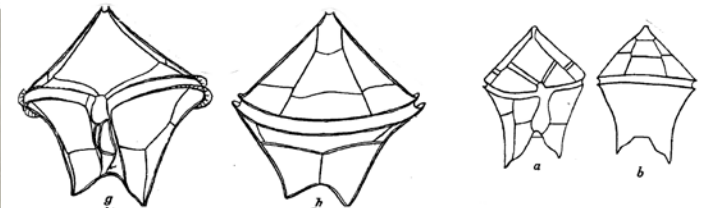
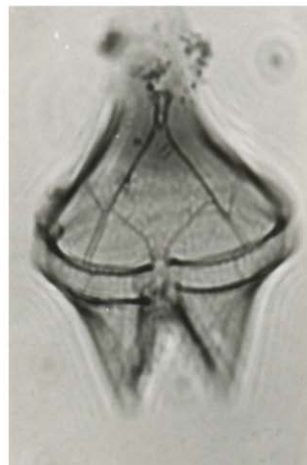
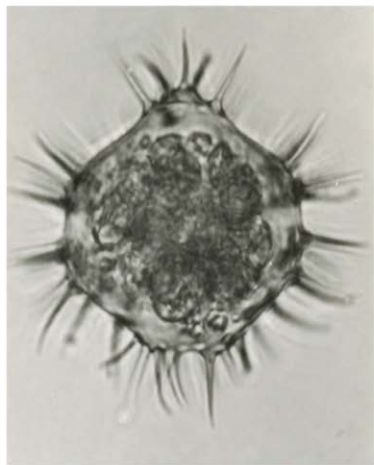
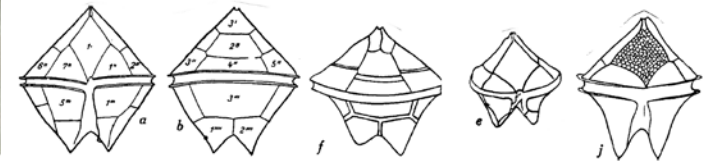
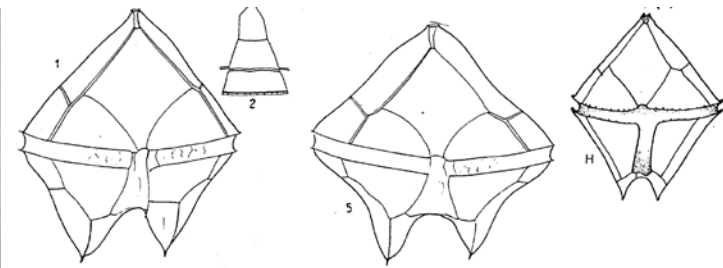
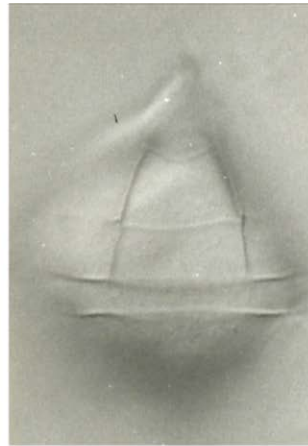
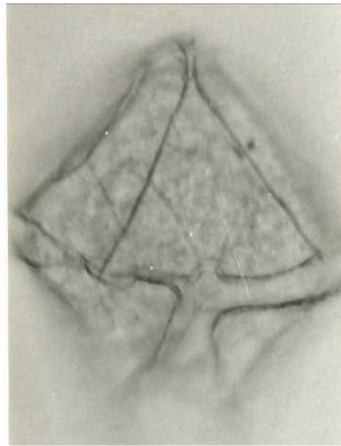
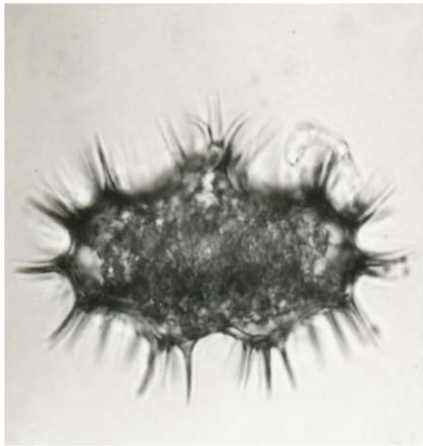
Protoperidinium
pentagonum ?

- 発芽細胞に形態異常が多い.
- 栄養細胞の分類が混乱している.



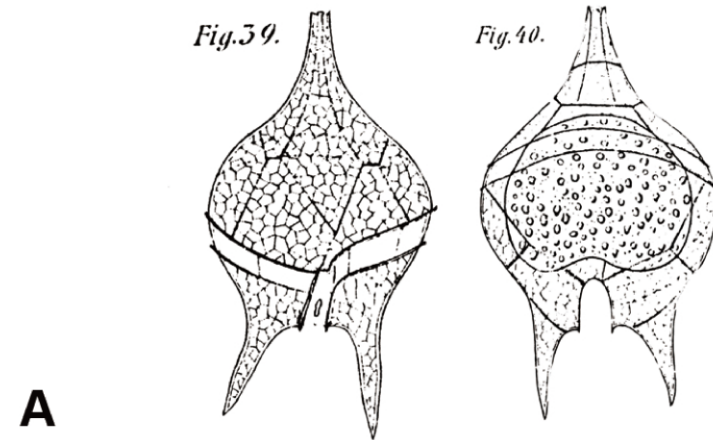
*Protoperidinium pentagonum*の形態上の多様性の意味は？

Protoperidinium conicum ; シストと発芽遊泳細胞

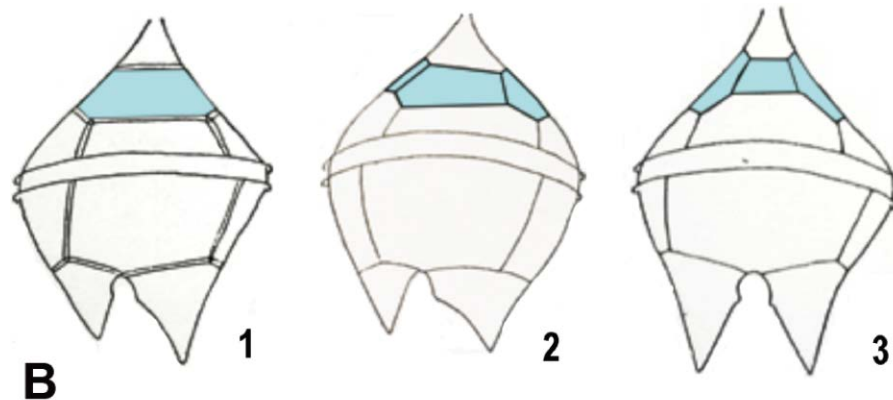


形態上の多様性(個体変異)なのがあるいは別種なのか

Protoperidinium oblongum complex の場合



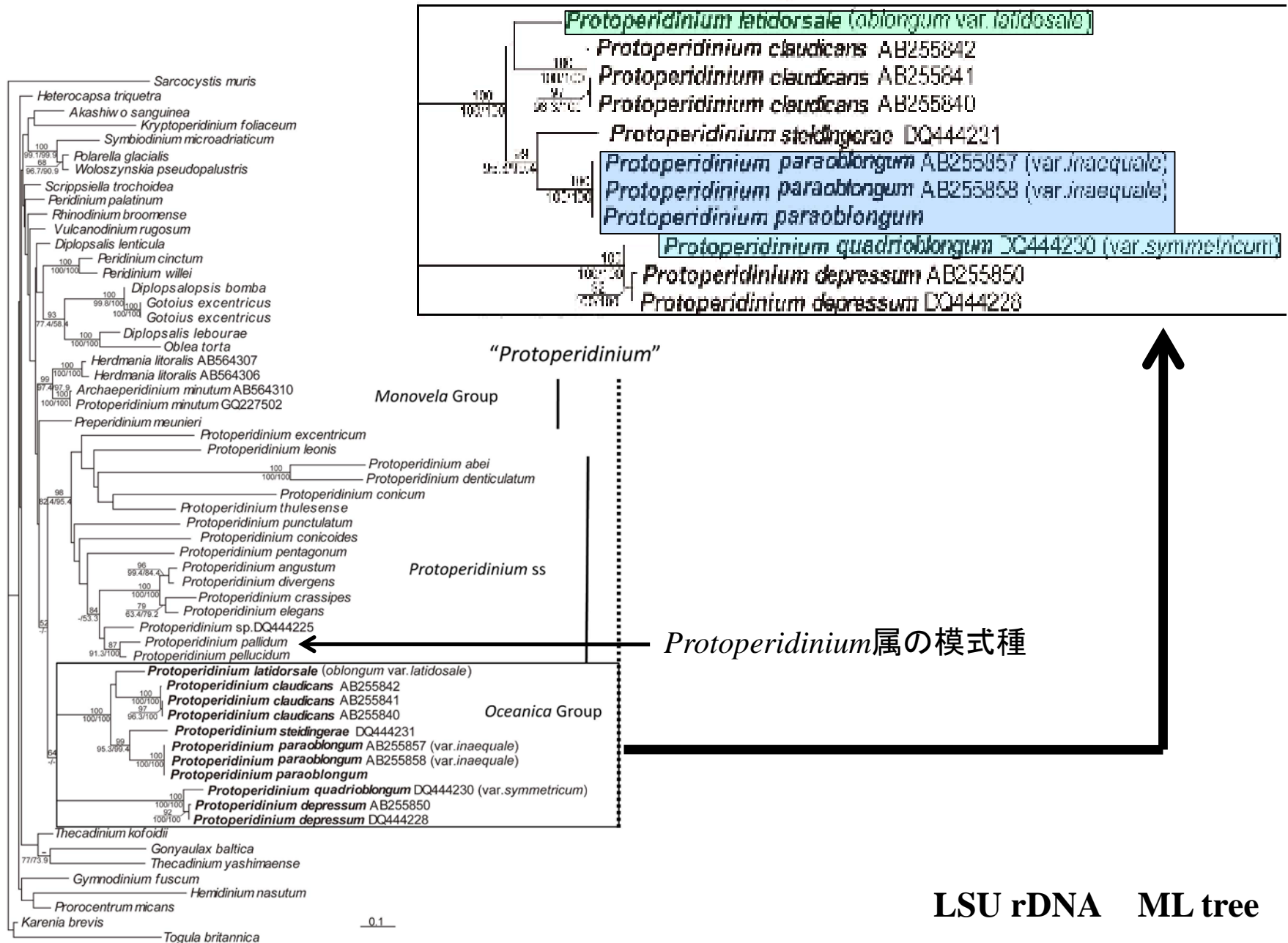
Berg 1882



Dangeard 1927

A *Peridinium oblongum*
B1 var. *latidosale*, B2 var. *inaequale*, B3 var. *symmetricum*

Protoperidinium oblongum 種群と分子系統解析



LSU rDNA ML tree

Protoepridinium oblongum 種群のシストと遊泳細胞

Rhomboidal

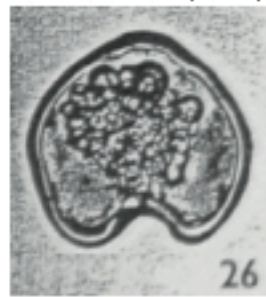
Wall et Dale (1968)



Metaquadra?
detached

Cordate

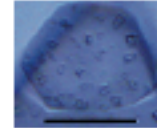
Wall et Dale (1968)



Hexa
adherent

Pentagonal

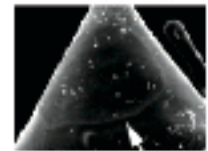
This study



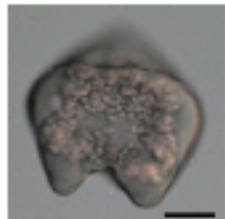
Penta
detached

Horned

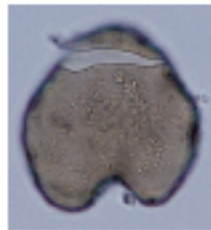
Wall et Dale (1968)



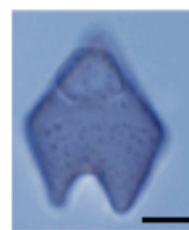
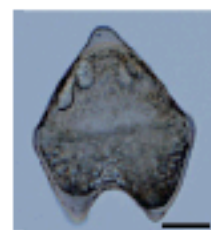
Hexa
adherent



3a, quadra



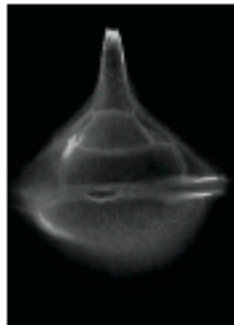
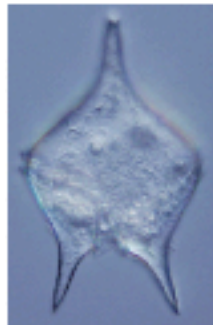
1a, hexa



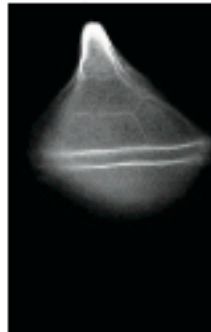
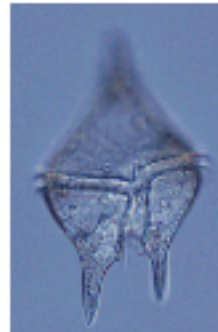
3a, penta



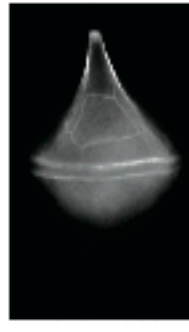
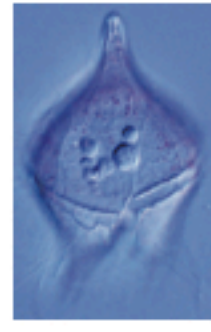
1a, hexa



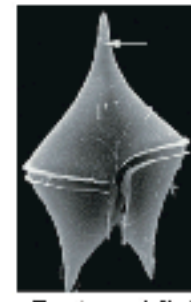
Protoepridinium quadrioblongum
This study



Protoepridinium latidosale
This study

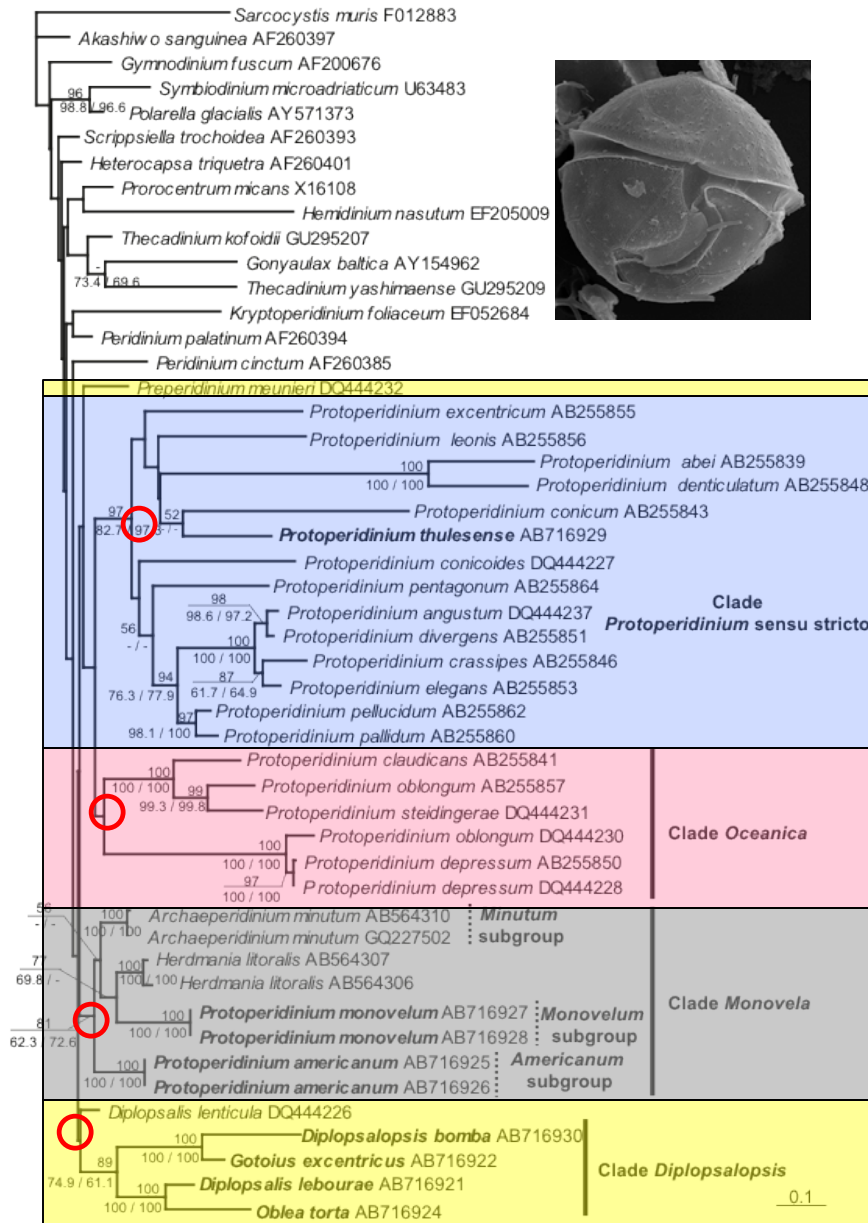


Protoepridinium paraoblongum
This study



Protoepridinium steidingerae
Gribble et al. 2009

Protoperidinium科の分子系統樹



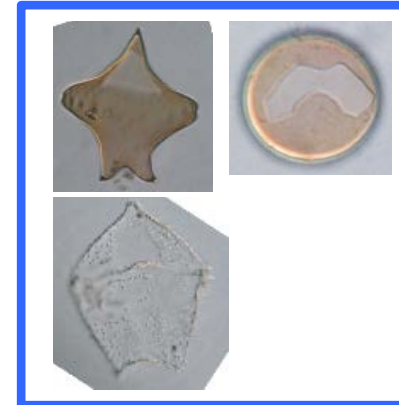
Protoepridiniumの系統分類はどうなるのか？

Subgenus *Archaeoperidinium*
Section *Avellana*
Section *eccentrica*

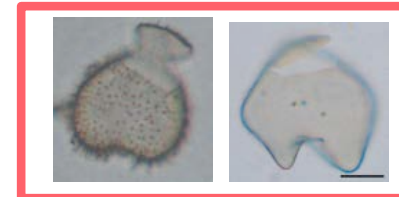
Subgenus *Protoperidinium*
Group *Orthoperidinium*
Section *Conica*
Group *Metaperidinium*
Section *Divergentina*

Group *Paraperidinium*
including the type species;
Protop. pellucidum

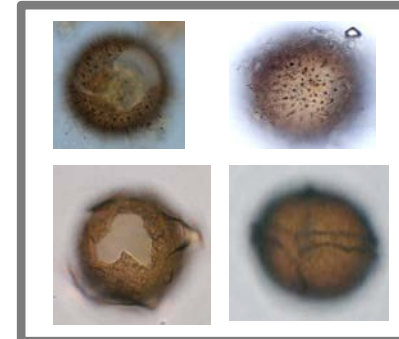
Subgenus *Minuscula*



Subgenus *Protoperidinium*
Group *Orthoperidinium*
Section *Oceanica*
Section *Tabulata*



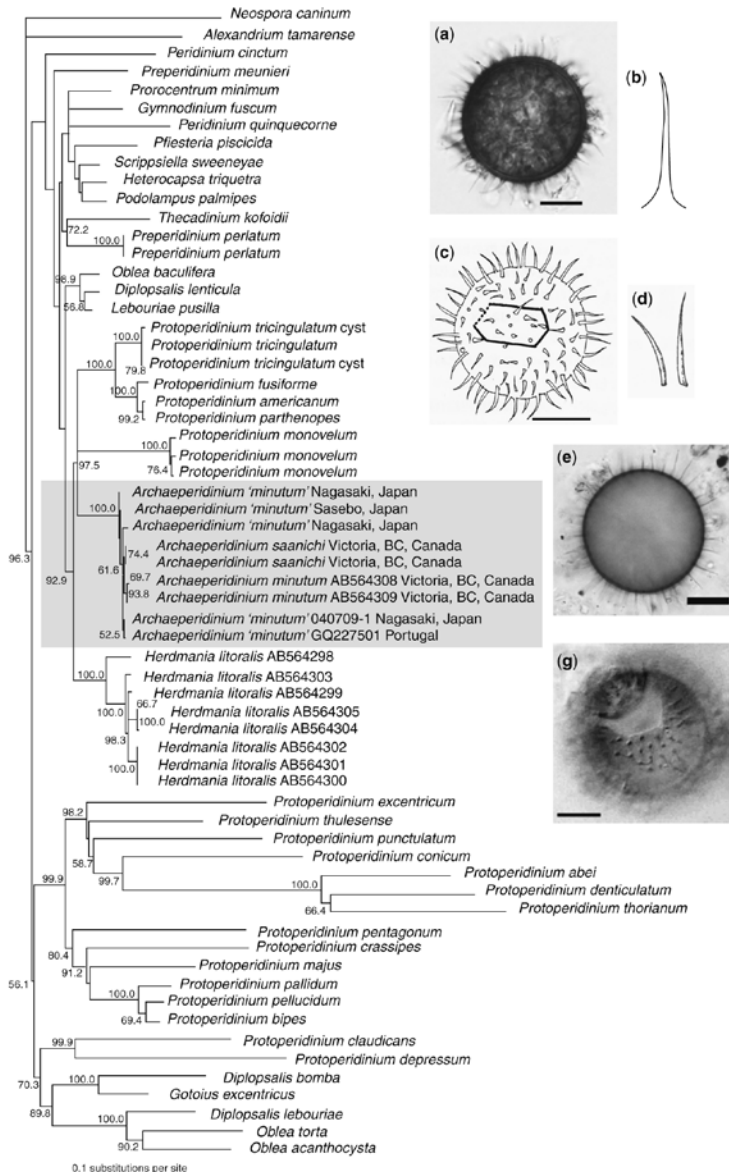
Monovela Group



Note; Diplopsalid group is also separated into two groups



Archaeoperidinium minutum complex とシスト



シストの形態は種を反映する

シスト研究者は細分主義者
(スプリッター; splitter) ではない。
シスト形態の相違は種を反映している。

Cryptic species (隠蔽種)の発見

生物は想定以上に多様である

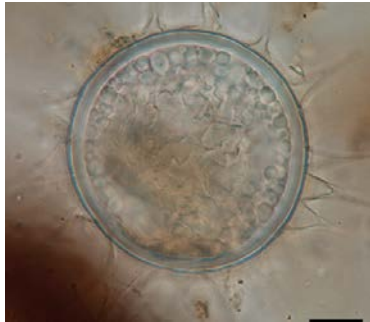


生きている化石と生物多様性ホットスポット —東南アジアの渚から—

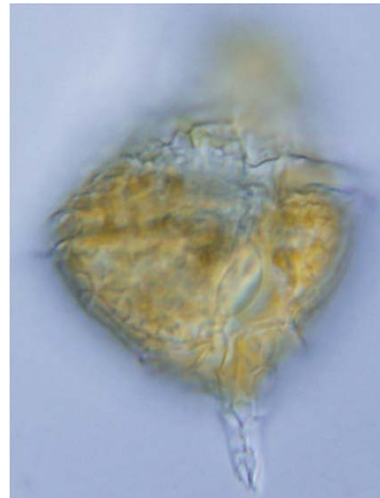


生きている化石の発見

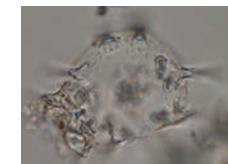
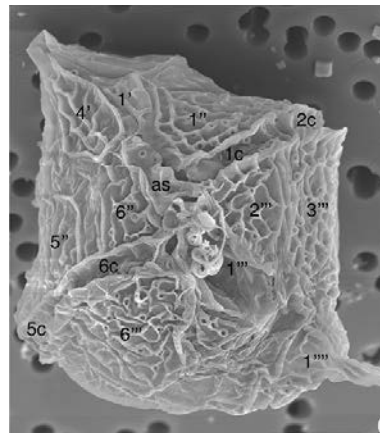
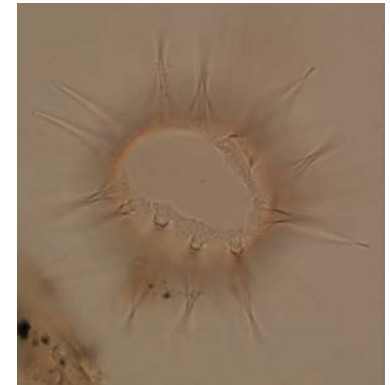
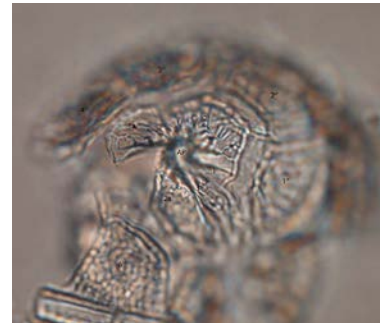
原形質で充たされた休眠細胞



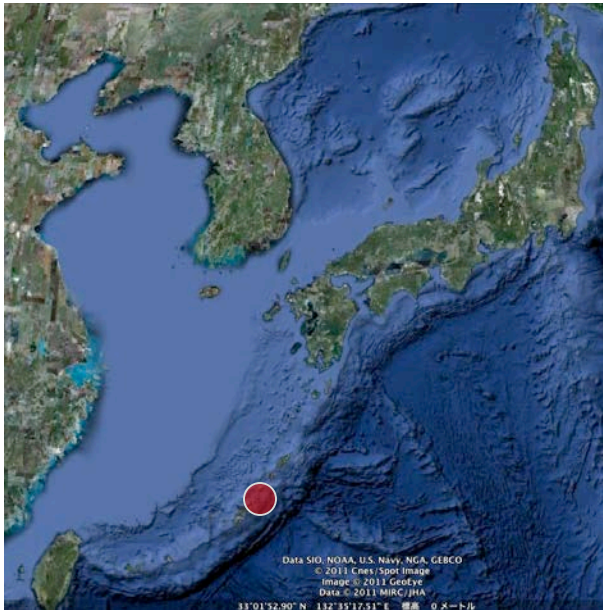
発芽してきた遊泳細胞



発芽後の休眠細胞

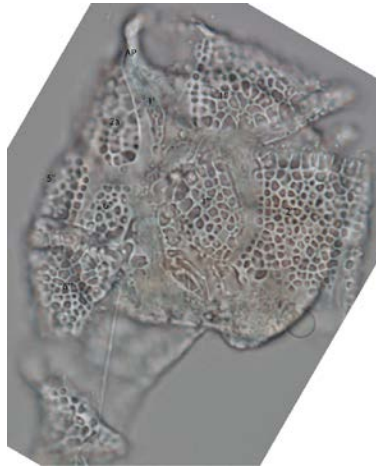
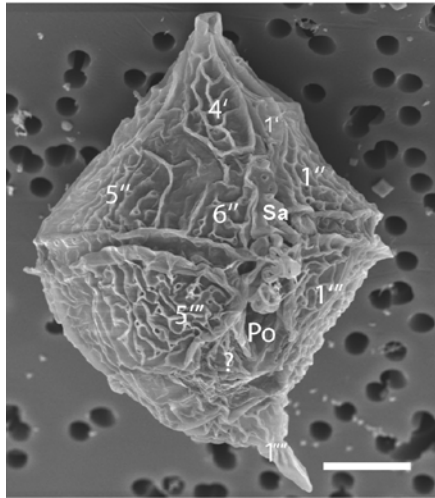


発芽蓋



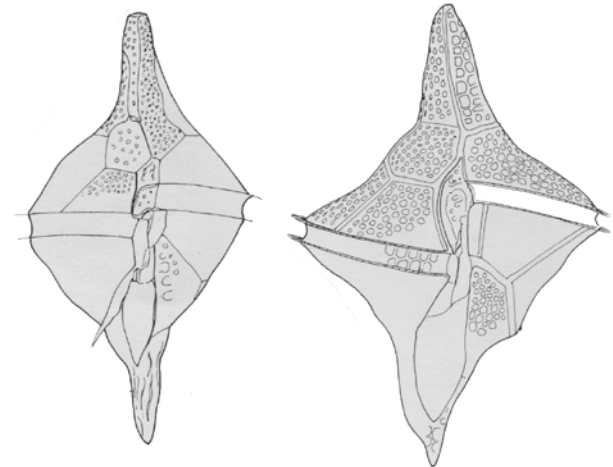
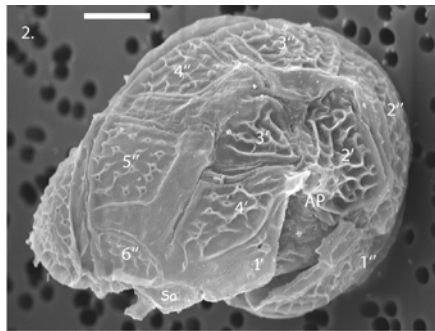
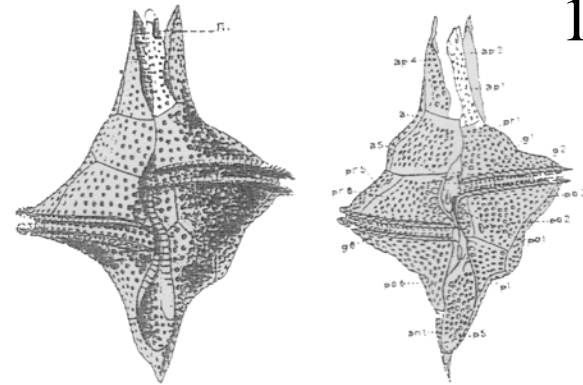
沖縄島・塩谷湾

生きている化石の発見

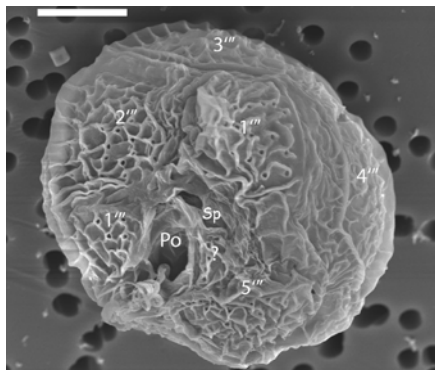


鎧板配列; Po, 4', 6", 6c, 7s, 6''', 1p, 1''''
 1"と6"は接していない.
 紡錘形で、後刺が発達.

1a plate



鎧板配列
 ↓
 Gonyaulacales



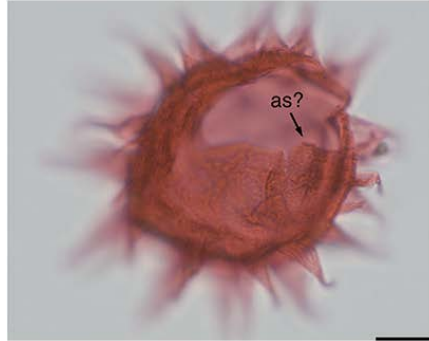
既報告の現生種はない

既に化石種として記載

Dapsilidinium pastielsii (Davey et Williams) Bujak, Downie, Eaton et Williams 1980

化石

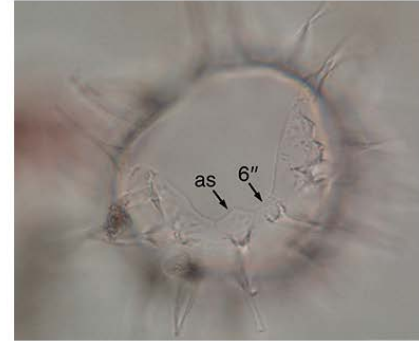
Holotype; Late Eocene; 40Ma



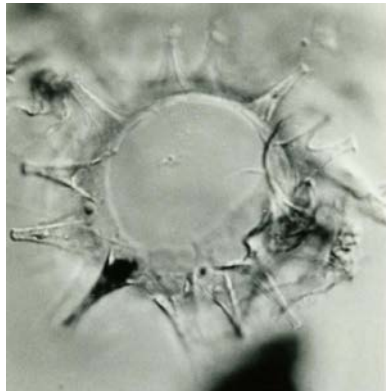
Early Oligocene



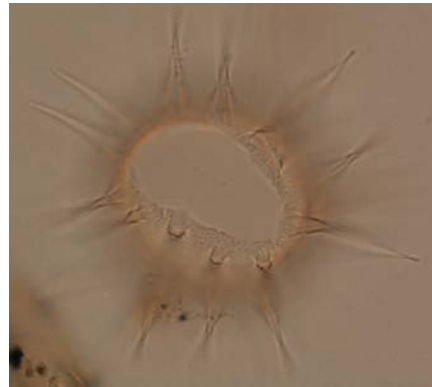
Middle Miocene



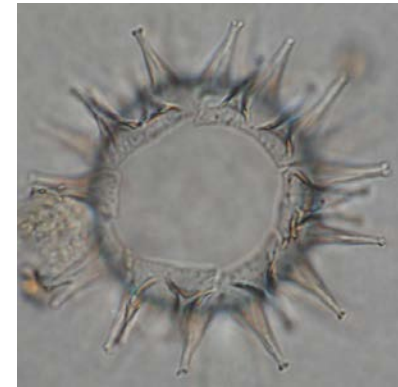
現生



Masinloc
Philippine



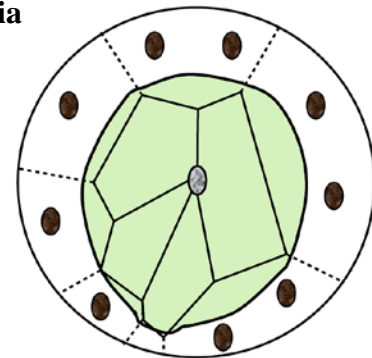
Ambon Bay
Indonesia



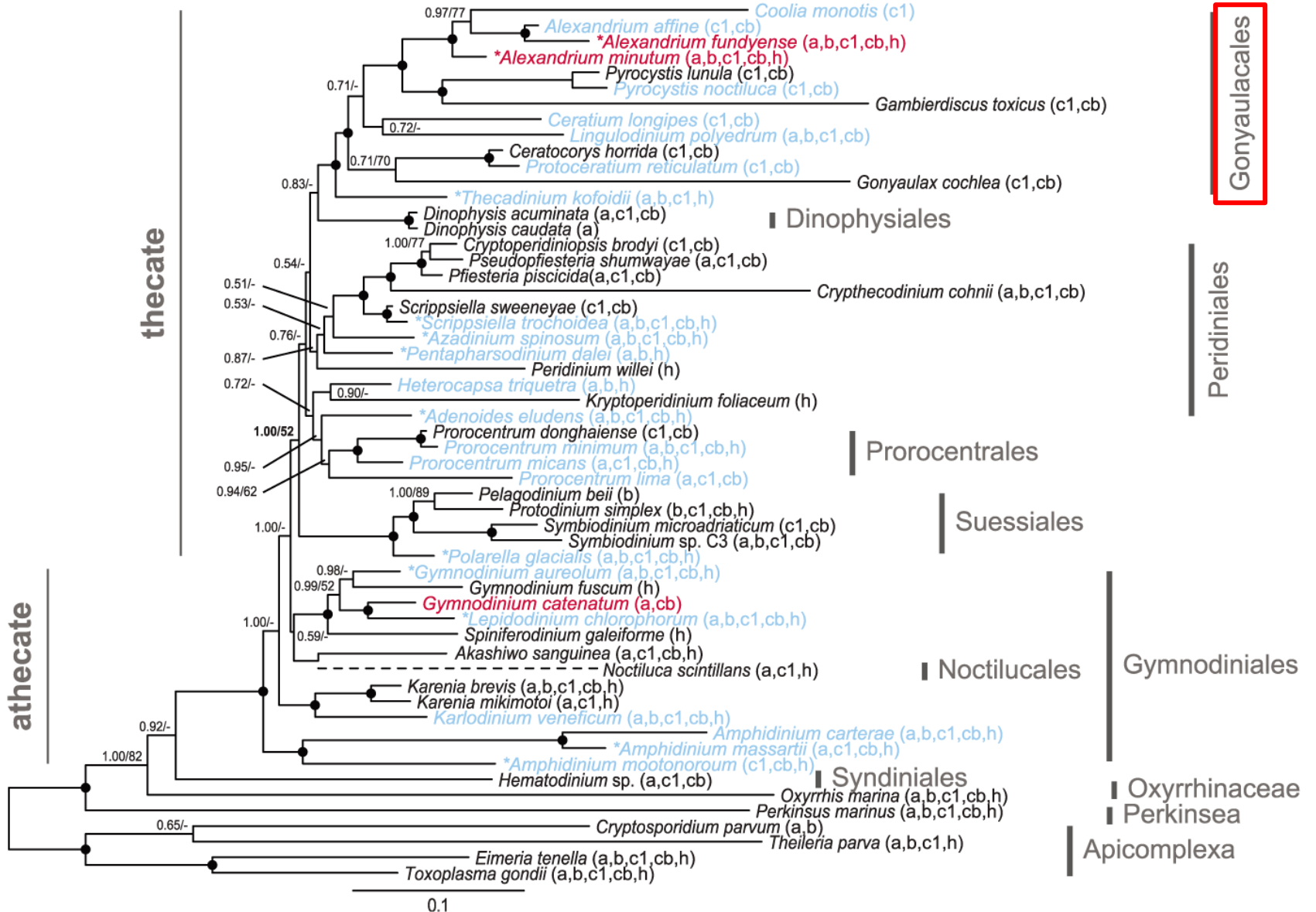
Lampung Bay
Indonesia

亜球形～卵形,
長い三角形で先端が裁断された多数の中空突起物,
突起物の偽鎧板内配置
多角形の発芽孔

刺と発芽孔(シスト)
と鎧板(遊泳細胞)
の対応関係

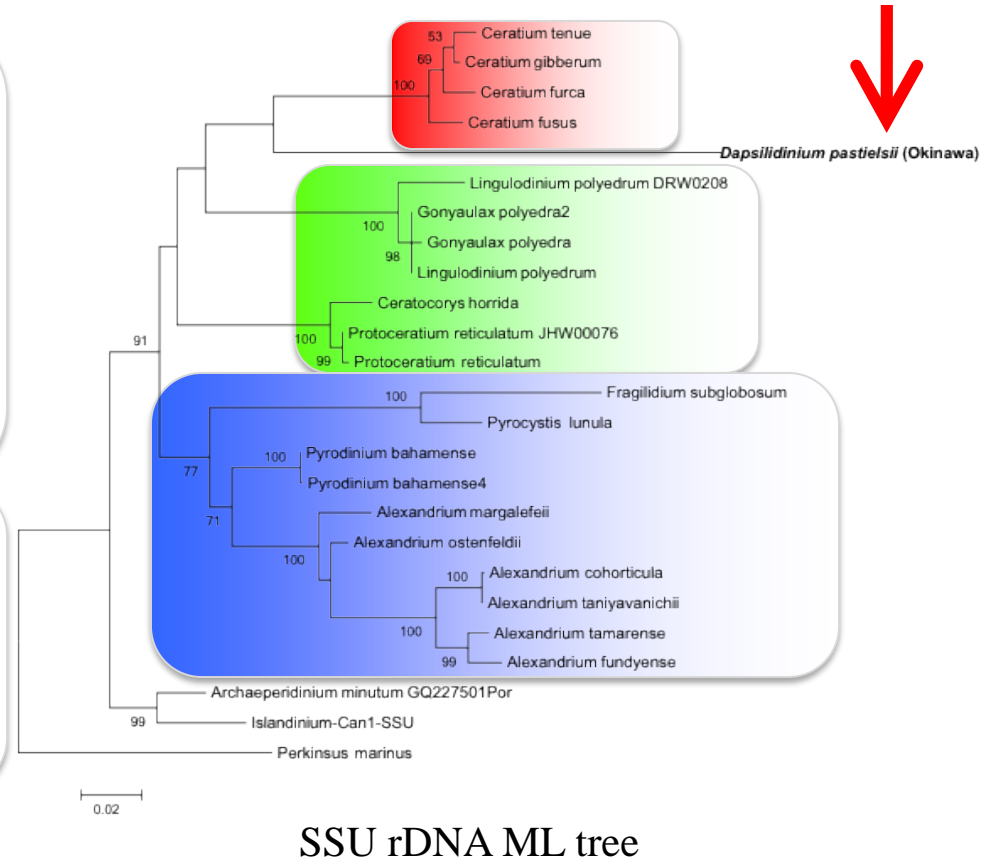
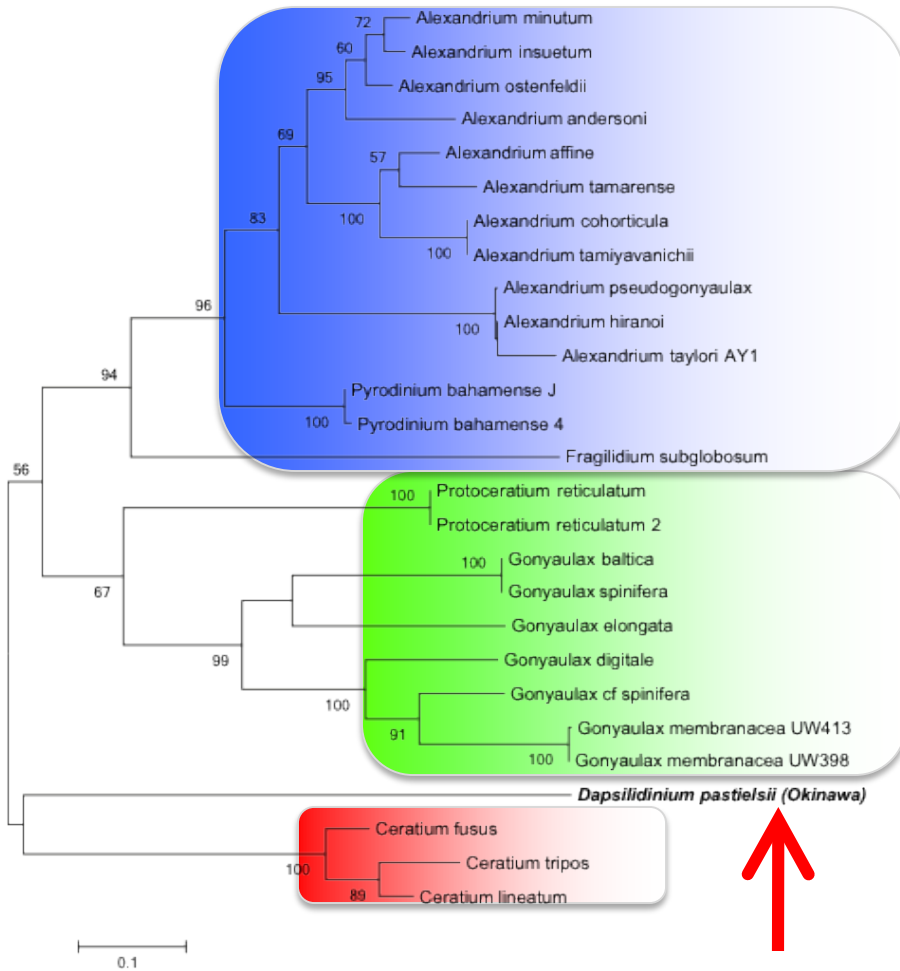


現生渦鞭毛藻の分子系統樹



Phylogenetic tree of dinoflagellates inferred from rDNA, mitochondrial and nuclear protein genes (reduced phylogeny). Concatenated phylogeny, inferred from 18S+5.8S+28S+cob+cox1+actin+beta-tubulin+hsp90 (7138 characters). (Orr et al 2012)

*Dapsilidinium pastielsii*の分子系統解析が示す類縁関係

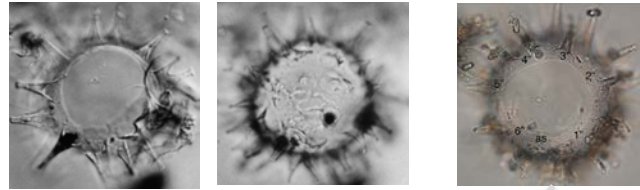


所属する分岐群はなく、
系統的に独立している

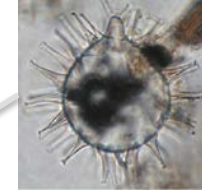
現生 *Dapsilidinium pastielsii* の地理的分布

Mascinloc

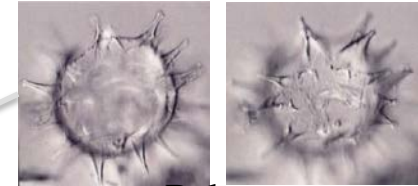
塩屋湾



Samar Sea

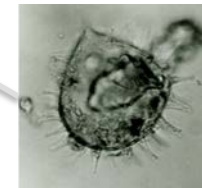
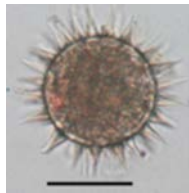


Myek

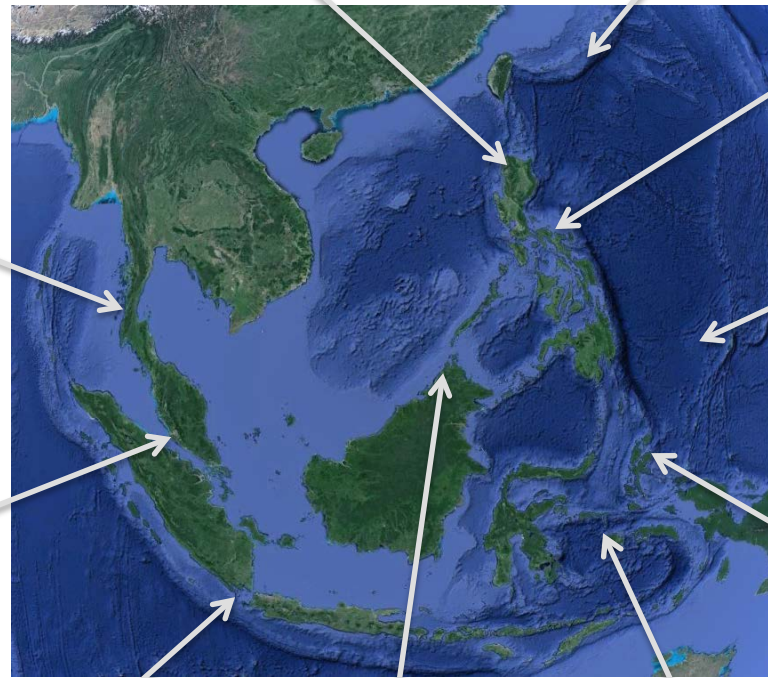


Palau

Selangor



Kao Bay



Hurun Bay

Sabah

Ambon Bay

東南アジア沿岸域に分布

化石 *Dapsilidinium pastielsii* (Davey et Williams) の出現記録

Holotype; Late Eocene; 40Ma



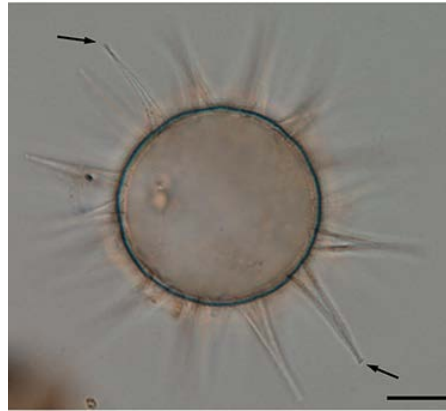
Late Eocene; 40Ma



Early Oligocene; 33Ma



Middle Miocene; 15Ma



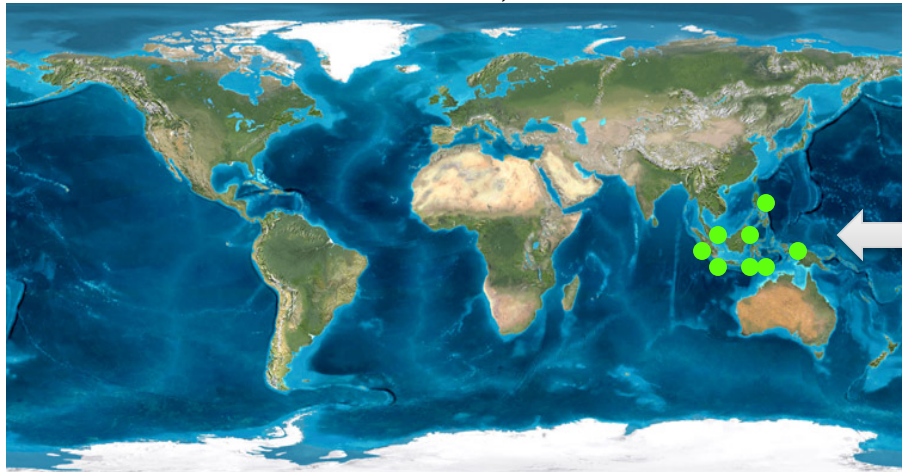
Early Pliocene; 5Ma



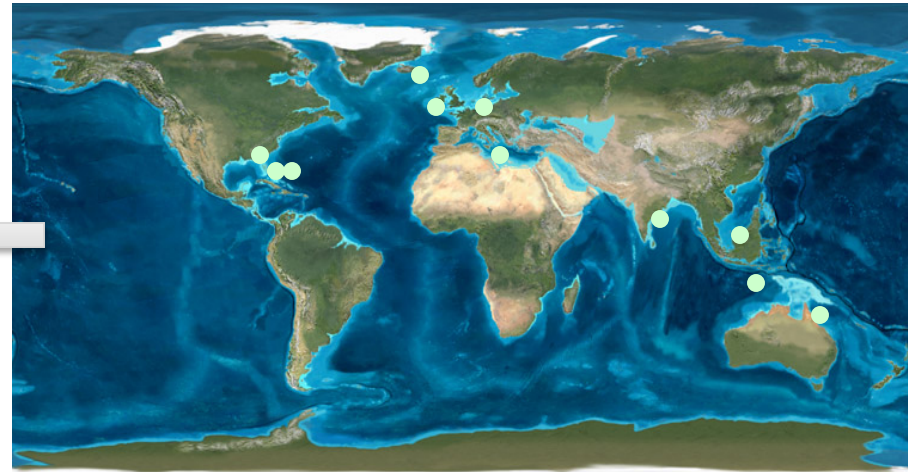
Early Pliocene; 4Ma

Cysts are large and chorate, and have an ovoidal central body with a finely granulate outer surface from which arises numerous hollow processes. The fine granulation continues beneath process bases. Processes are intratabular and most are fairly evenly spaced, tapering distally to a narrow neck before expanding minutely to an opening with entire or serrated/irregular margin. The processes are oval to circular in basal cross-section. Cysts may have two or three adjacent processes fused along most of their length. The archeopyle is apical corresponding to the four apical plates.

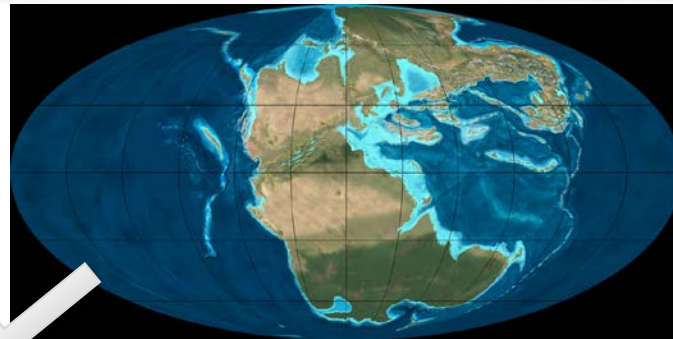
Holocene; 0.01-0Ma



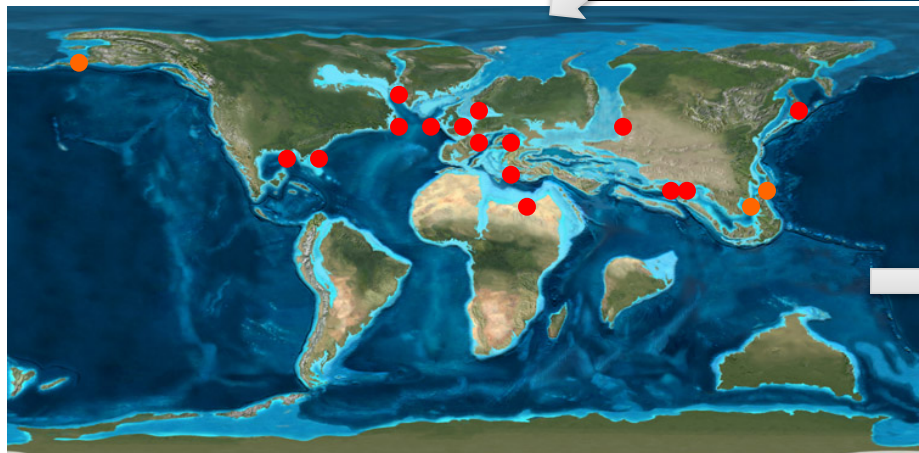
Pliocene; 5.33-2.58Ma



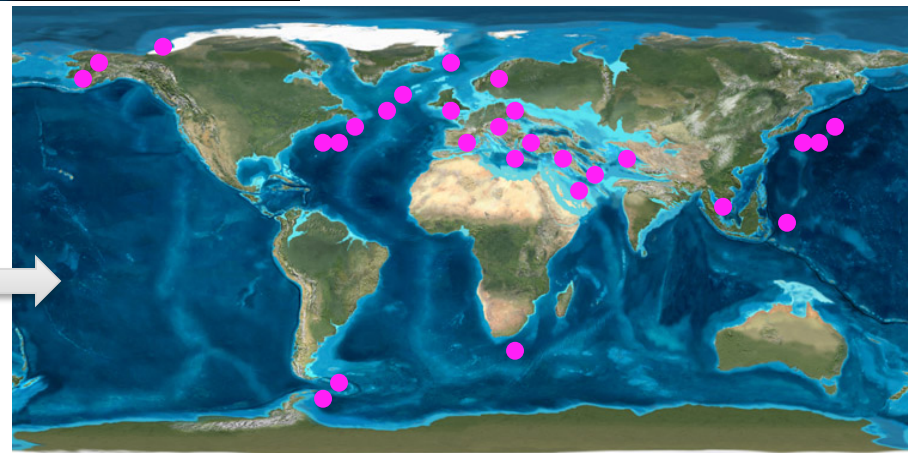
超大陸パンゲアの分裂



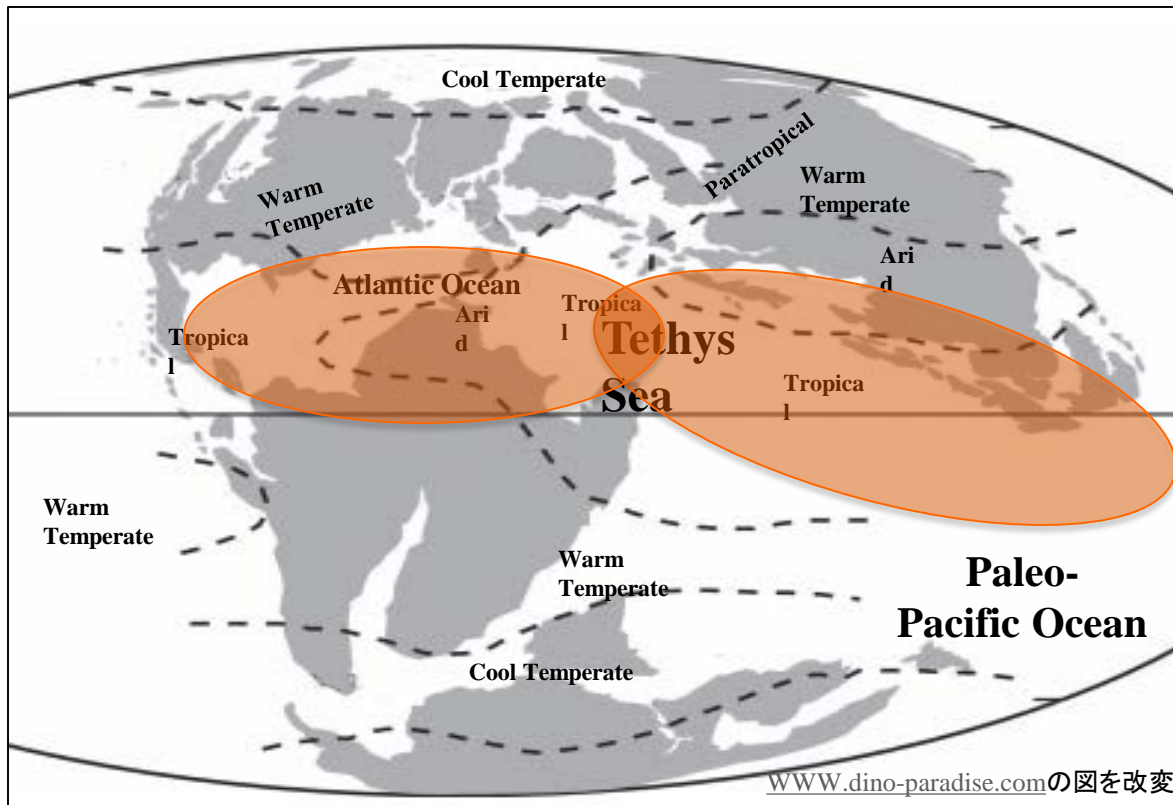
Jurassic; 200Ma



Eocene-Oligocene
53-23.5Ma



Miocene
23.5-5.3Ma

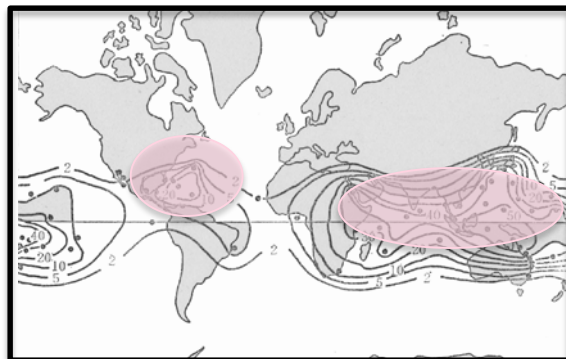


白亜紀(65Ma)の気候帯
テチス海は熱帯性

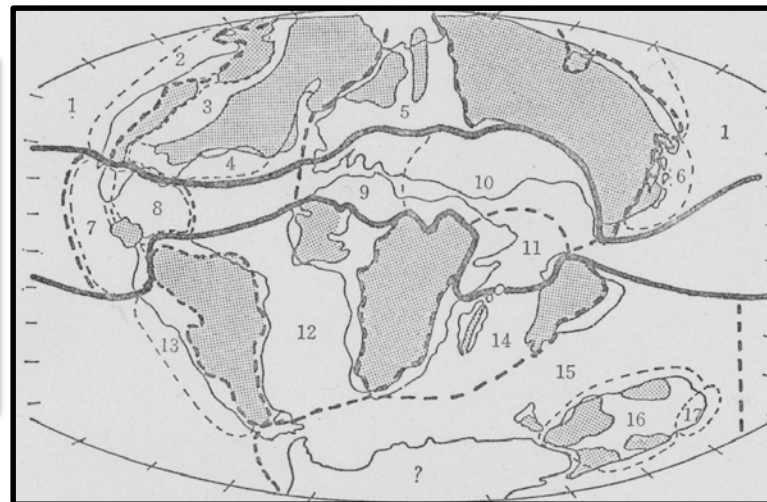
熱帯性インド洋-太平洋生物地理区と
カリブ海生物地理区の成立

*Dapsilidinium pastielsii*は
Tethys海要素の遺存種

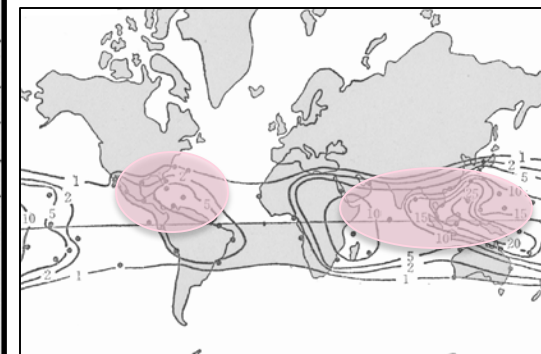
WWW.dino-paradise.comの図を改変



熱帯性スイショウガイ属の種数分布
(Staepli 1968)

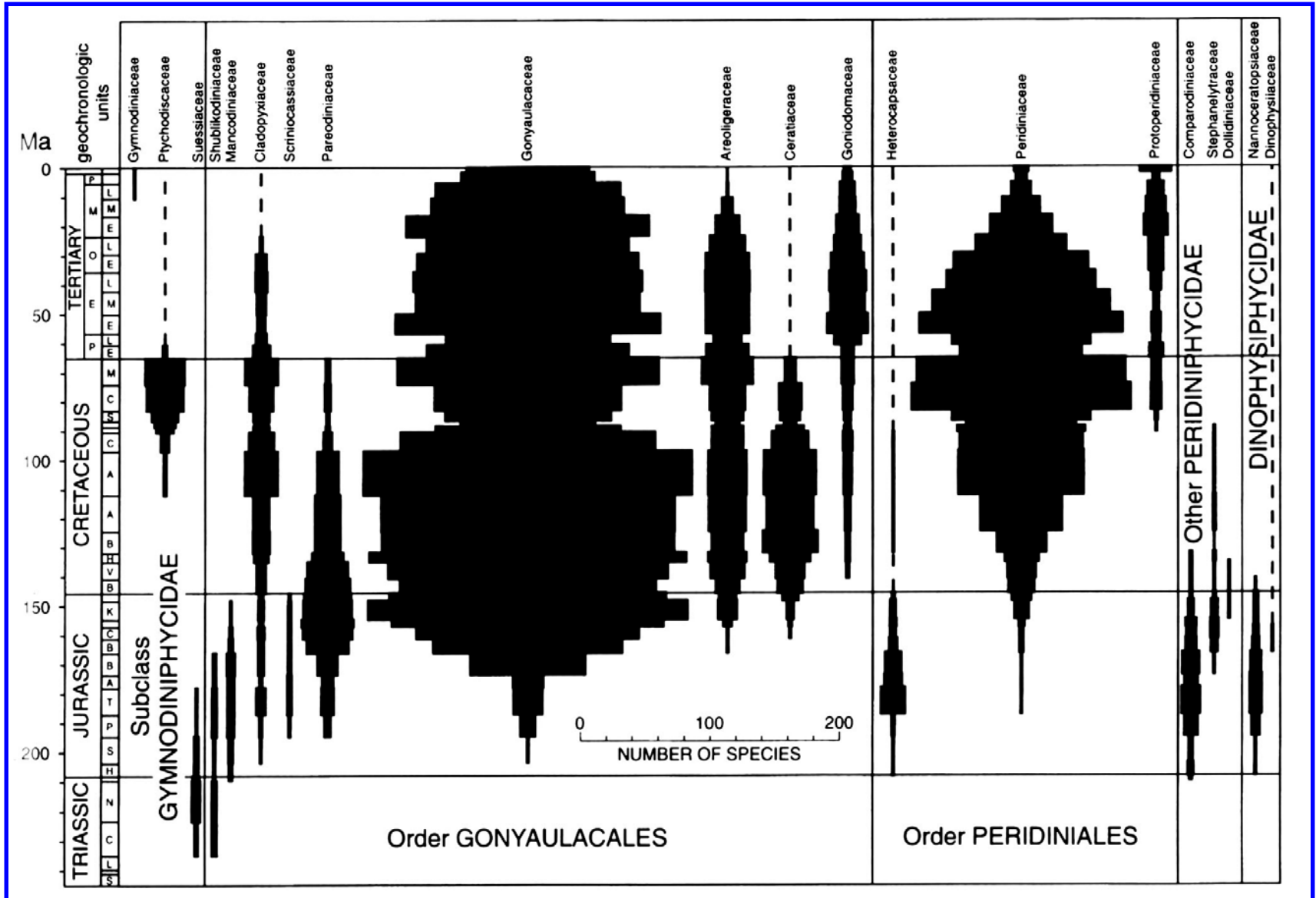


白亜紀の生物地理区 (Kauffman1973)

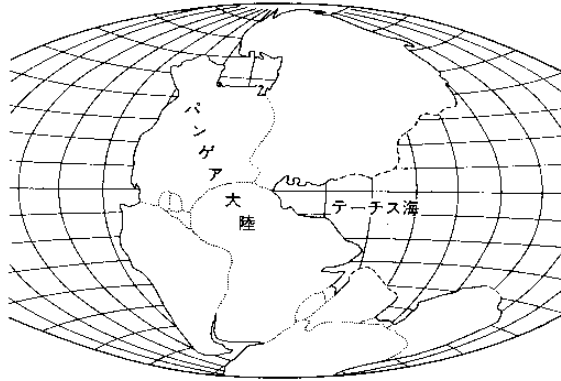


造礁性サンゴ類の属数分布 (Staepli 1968)

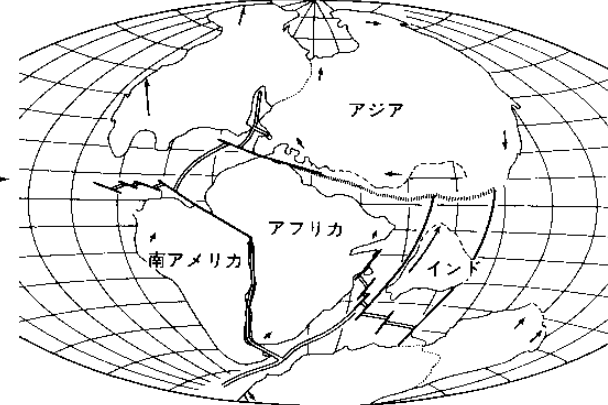
洞鞭毛藻化石多様性の変遷とPlate tectonics



パンゲアの分裂→沿岸海域の増加→沿岸環境の多様化

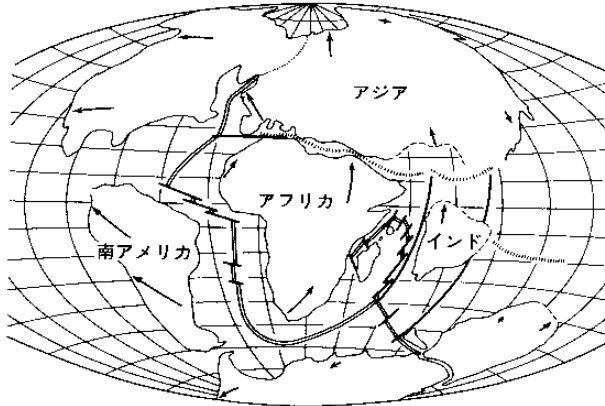


二畳紀の終り（今から約2億2500万年前）の世界地図
渦鞭毛藻類の出現



ジュラ紀の後半（約1億3500万年前）の世界地図

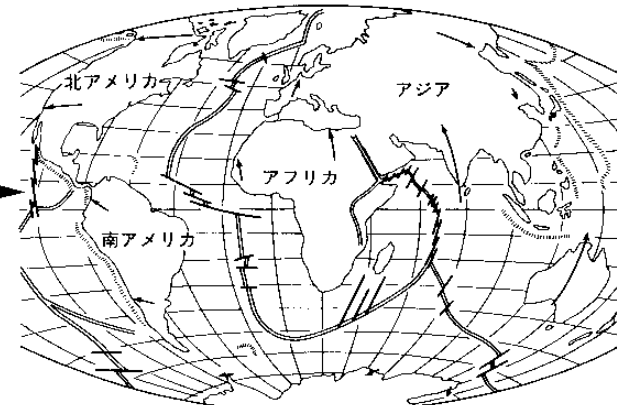
沿岸海域の増大



白亜紀の終り（約6500万年前）の世界地図

渦鞭毛藻類の多様化

(Dietz & Holden 1970 による)



現在の大陸と海嶺、海溝の分布

シスト形成は渦鞭毛藻の生き残り戦略

渦鞭毛藻シストは環境変化と生物進化の 生き証人である

何気ない小さなプランクトンも地球の歴史を物語ることができる

生物はすべてからく環境と共存している

もちろん人間も

鳴謝

長崎大学環東シナ海環境資源研究センター・水産学部の皆さん
沿岸環境学研究室の皆さん
長崎大学の皆さん
調査研究遂行にご協力いただいた国内外の関係機関の皆さん

鳴謝

長い間のご協力・ご援助有り難うございました