Diatom as organism, diatom as tool: considerations in assessing environmental impact

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Diatoms have been applied successfully as environmental indicators in a number of fields
Yet, several issues remain that, if solved, would make diatoms more powerful tools

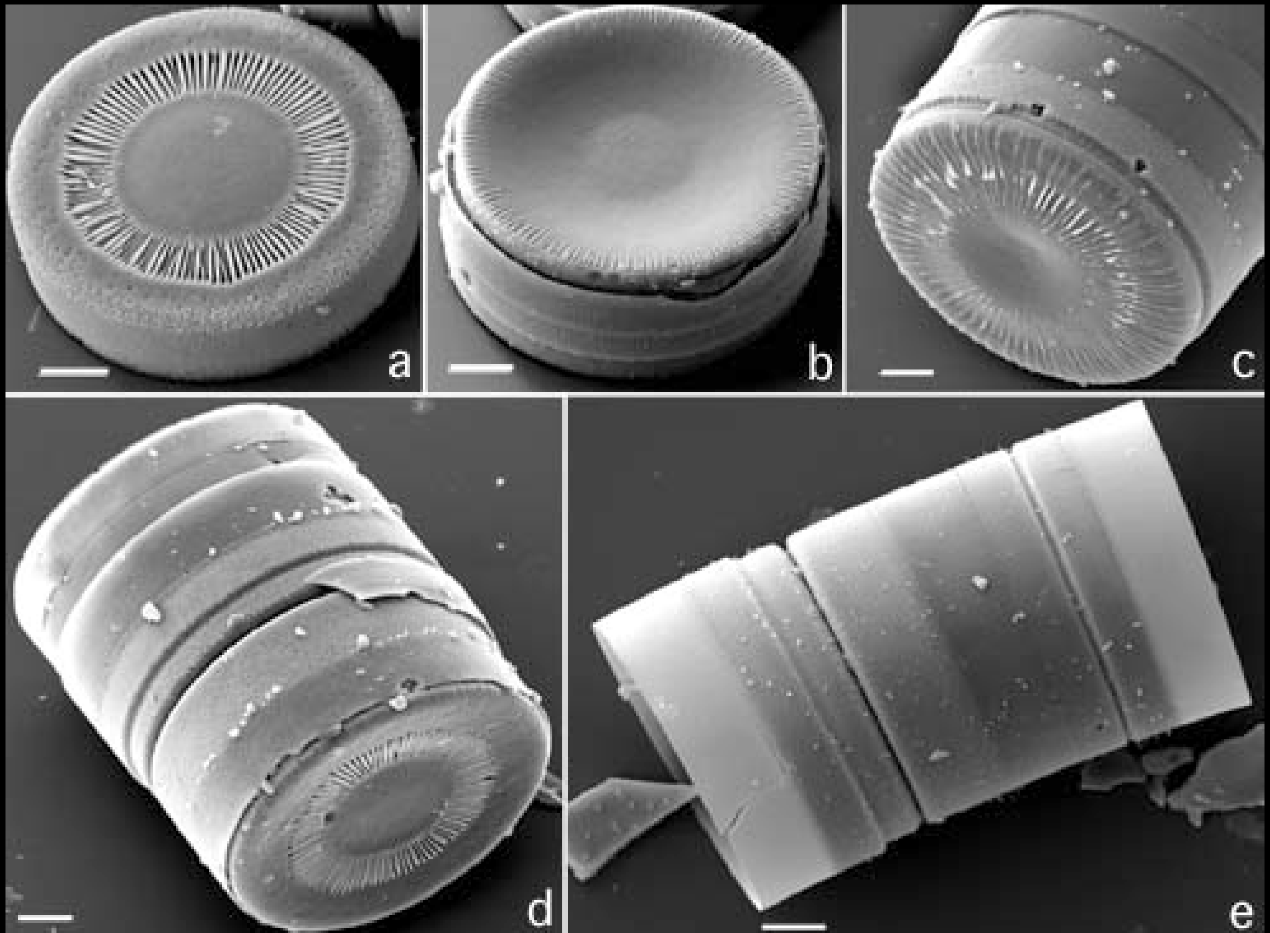
To make diatoms more useful as tools, we need to be more accurate

Consider species biology and autecology

Utilize indicator taxa

Recognize regional distributions of species

Deposit samples in permanent, publicly accessible archives



diatom

from Greek, meaning to "cut into two"


Science
AAAS

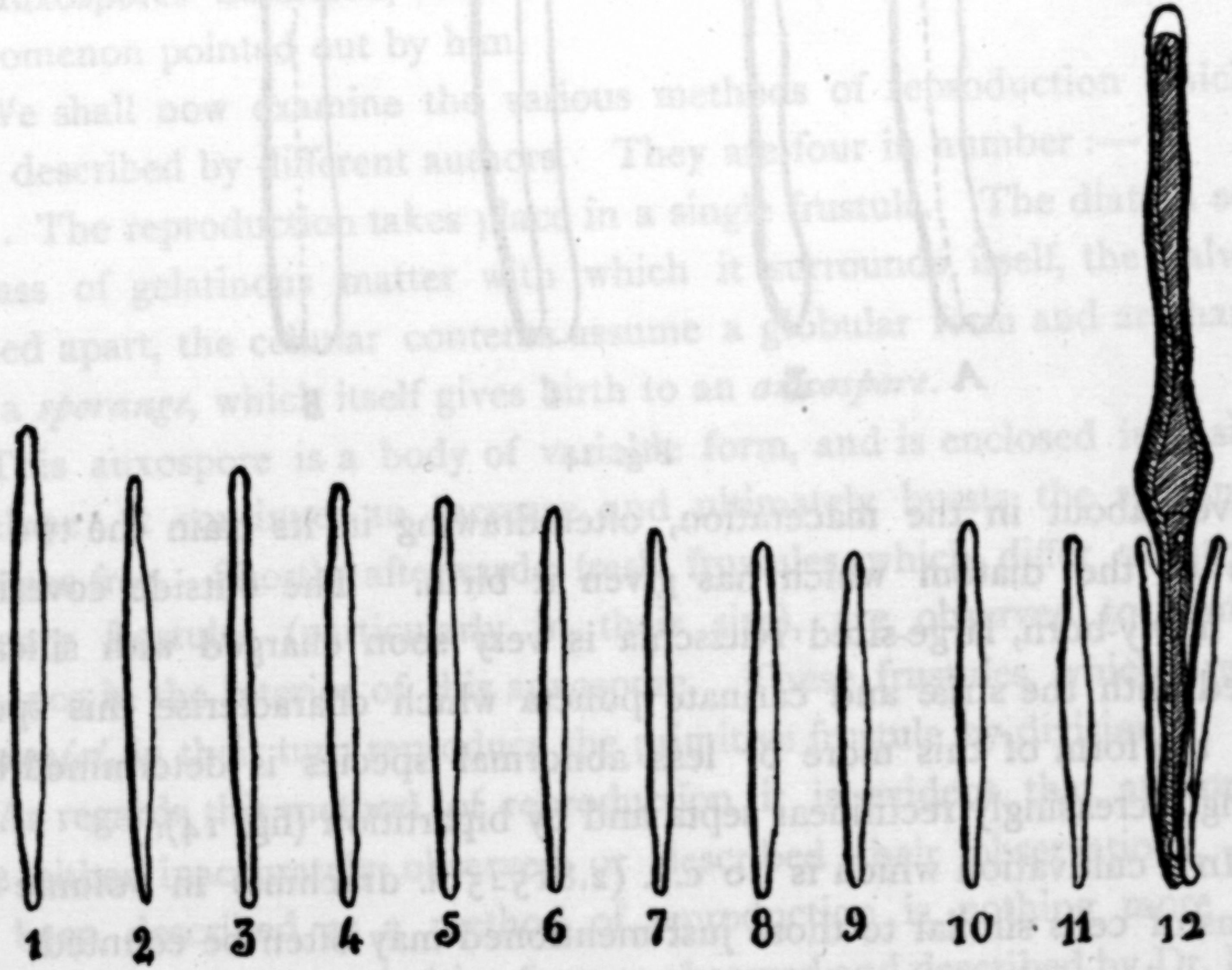
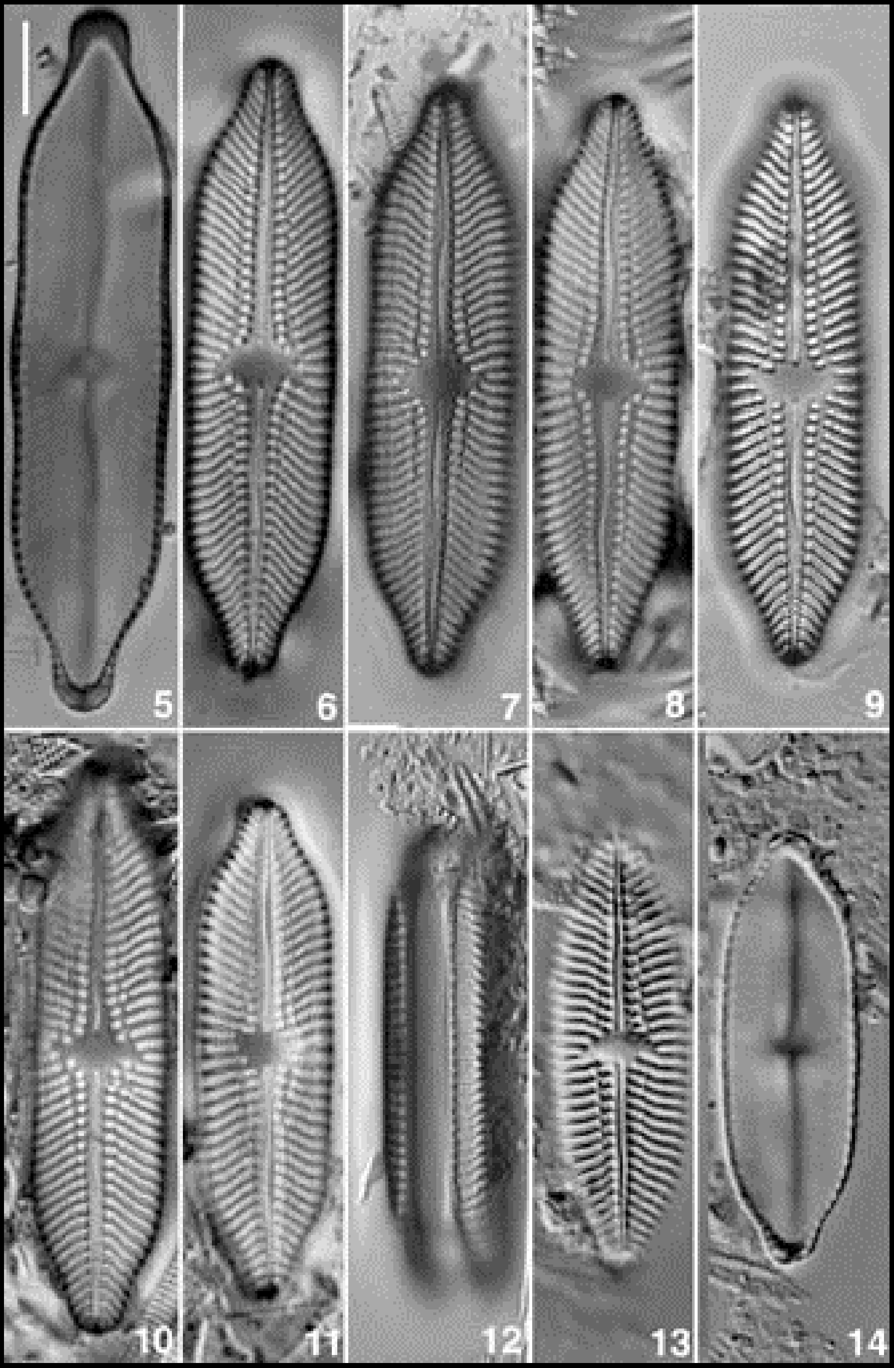


Fig. 12.

van Heurck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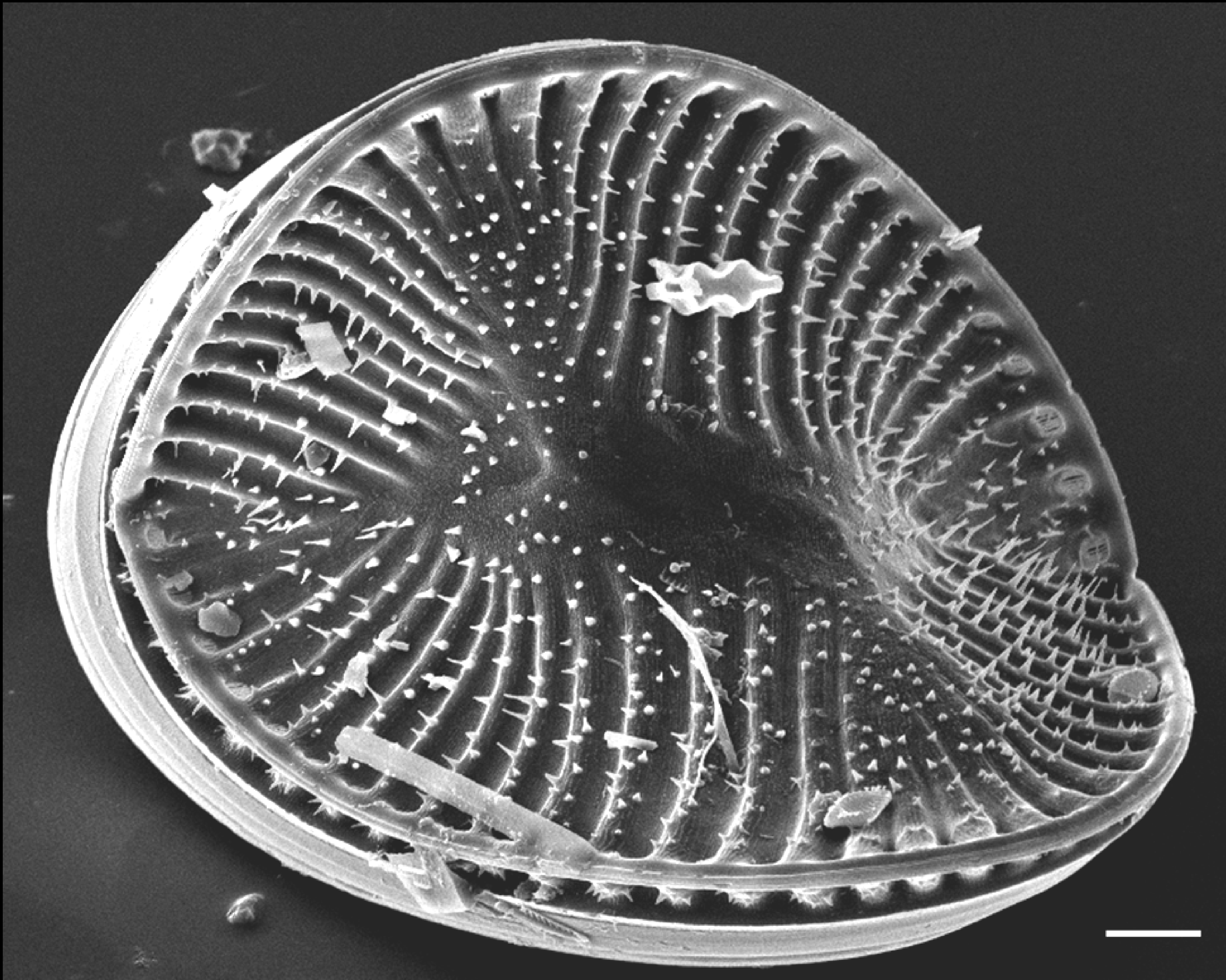


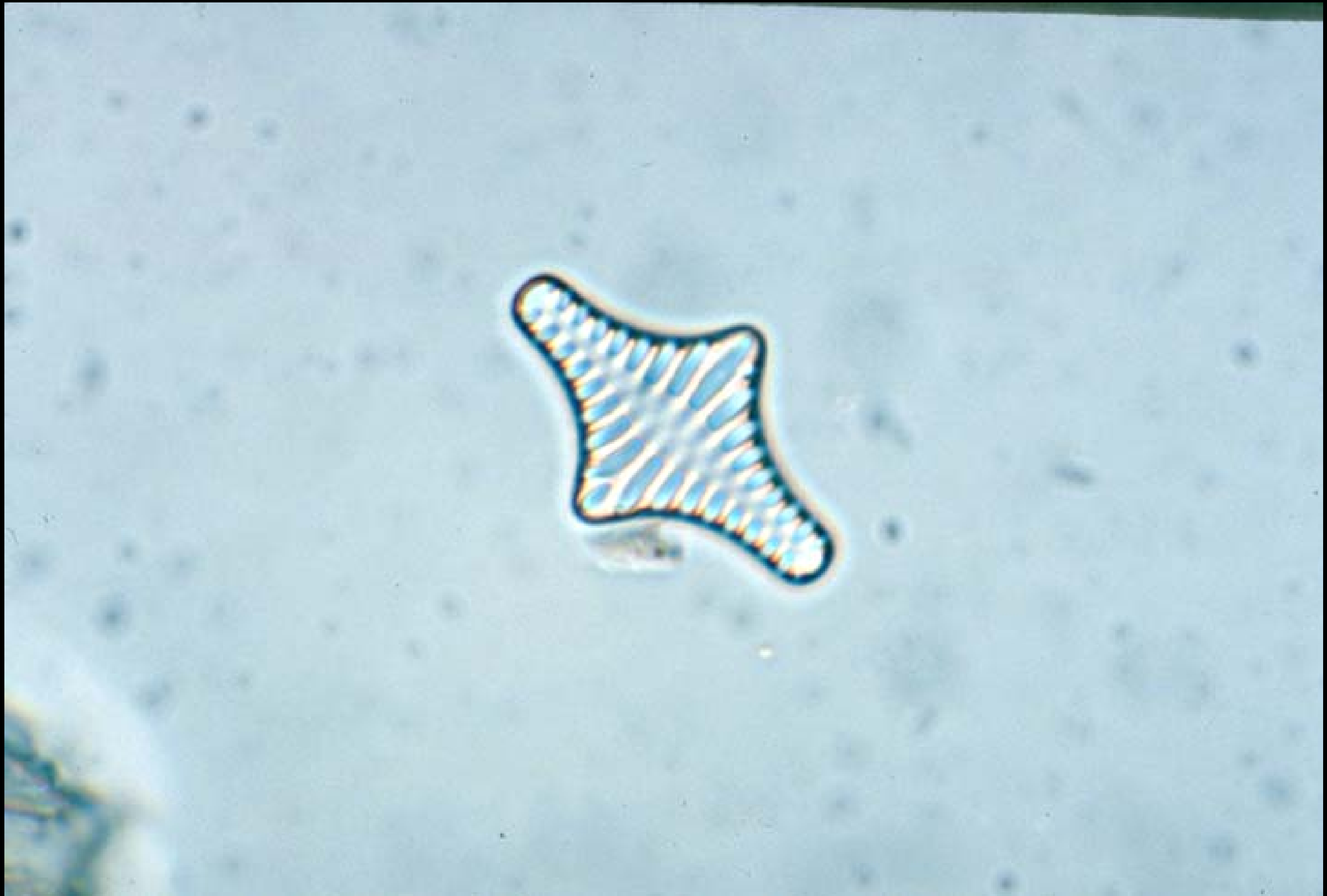
living colonies of *Meridion circulare*

Chloroplasts, cytoplasm in silica cell wall

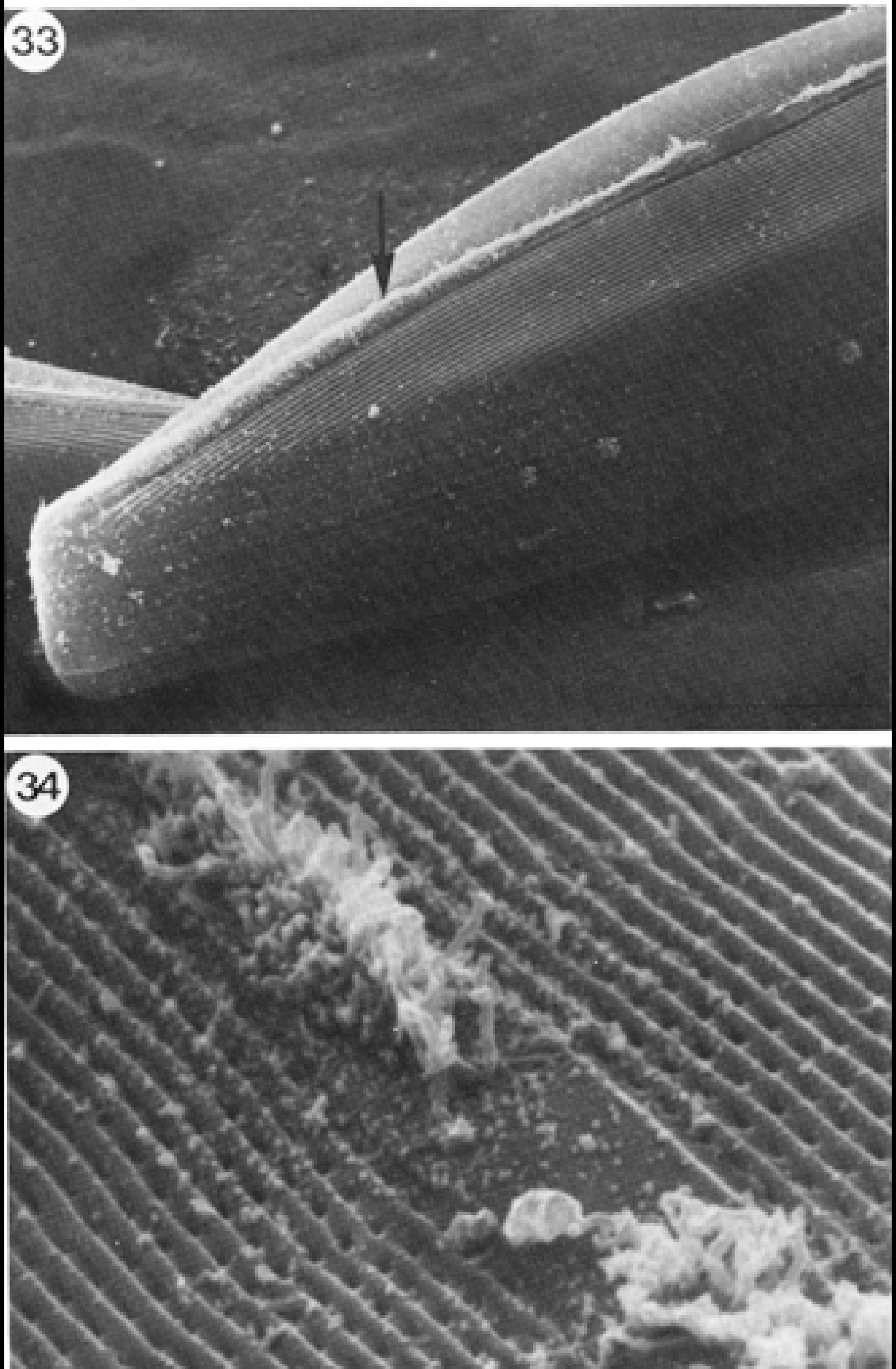
Staurosirella – genus separated from *Fragilaria* recently (1987)

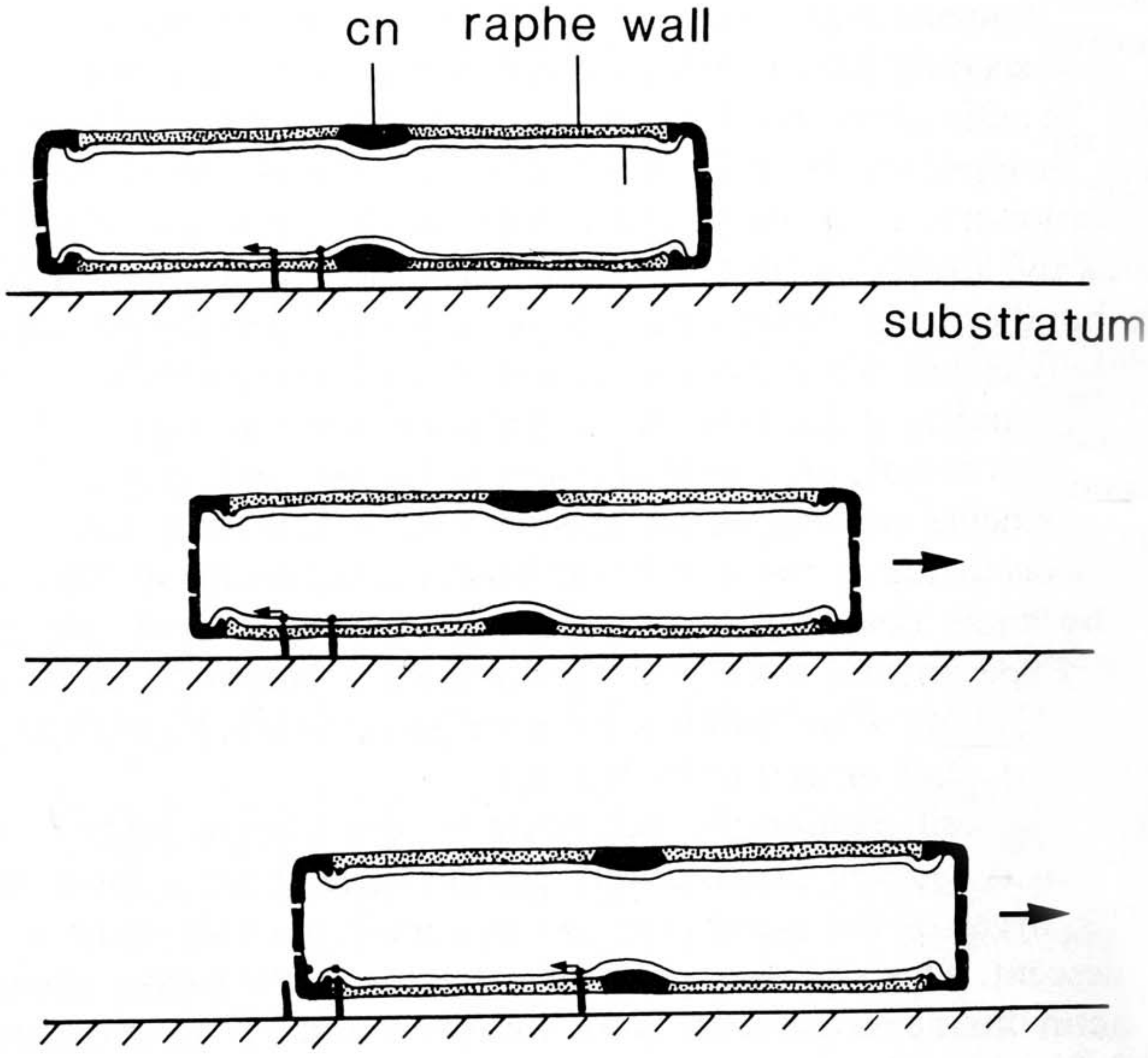
grows attached to sand grains, some planktonic species

example of recent nomenclatural changes reflecting ecological and habitat preference



mucopolysaccaride filaments extend through raphe slit, which are controlled internally by microtubules




cn
raphe wall
substratum

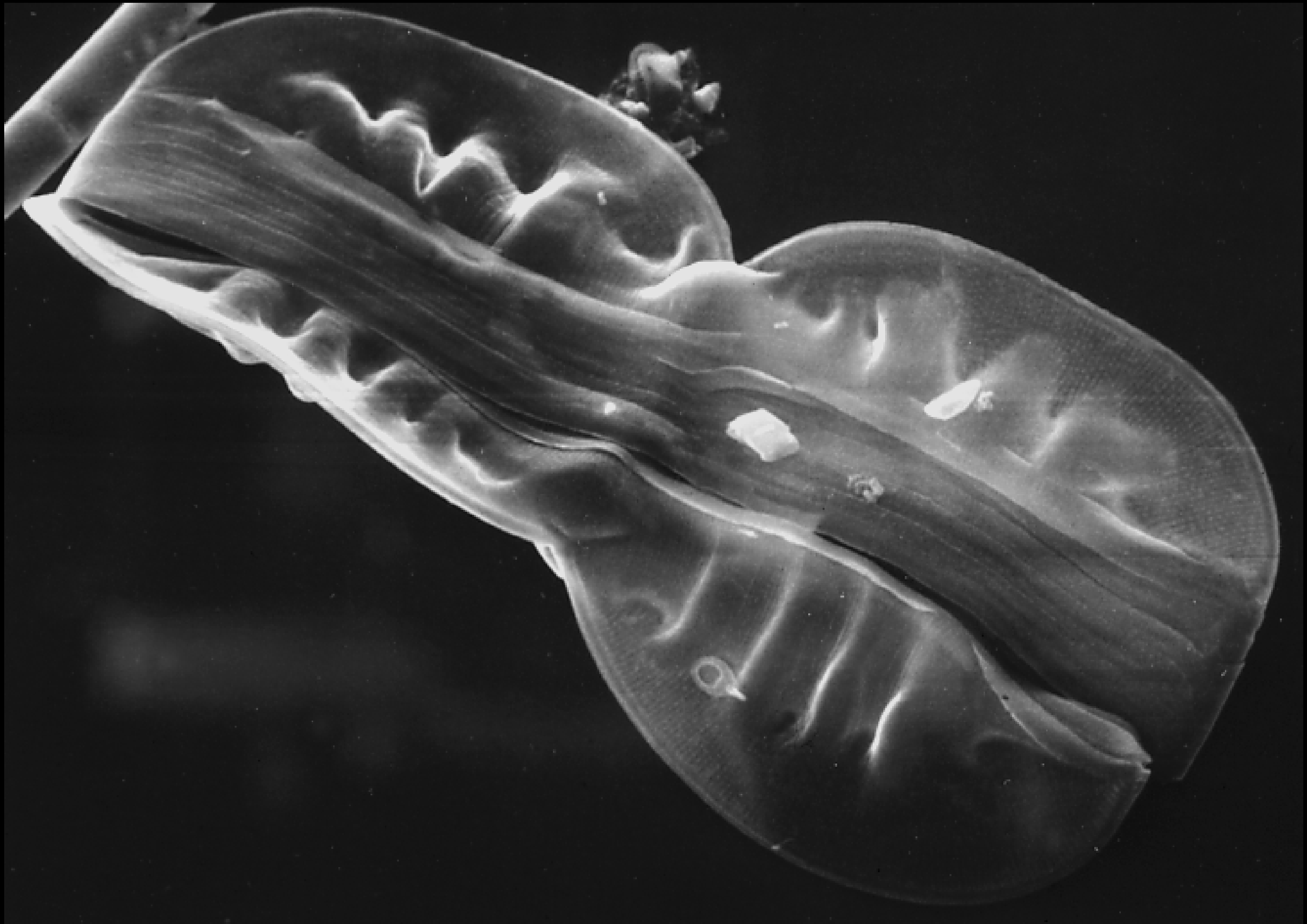
benthic, attached to substrate by mucilaginous stalks

160 species in the genus *Gomphonema* reported from North America, genus level distinction probably not helpful

includes "weedy" species (*G. parvulum*), and species considered to be endemic or rare, with narrow ecological tolerance

Encyonema minuta– widespread benthic species, attached to substrate by mucilaginous tubes, cells move within tubes

raphe well developed and raised onto a keel
the more raphe length, the greater the cell motility
Entomoneis ornata



Samples from flowing waters may have diatom valves that originated upstream.

Live cells

Dead cells

It is important to recognize that possibility -

Attached species

Planktonic species

Soil species

Utilize indicator taxa – abundant vs. rare species

- Do common, widely distributed species tend to exhibit wide ecological tolerances?

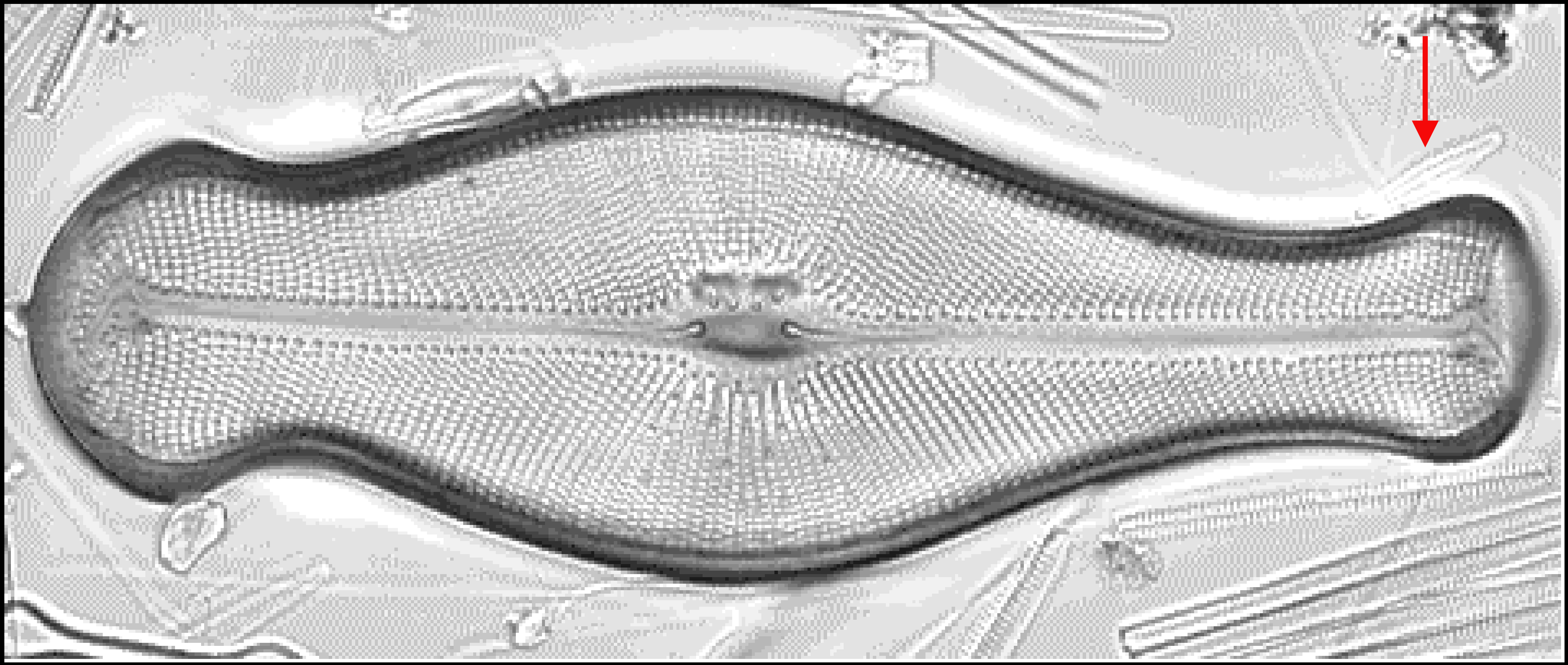
Abundant taxa

- A small diatom (*Achnanthidium minutissimum*) may dominant samples
- Analyses are based on counts of 600 diatom valves (300 cells)
- *A. minutissium* determines the precision of counts of rare taxa

invasive species? it has huge cells, grows on stalks in fast flowing,cold waters

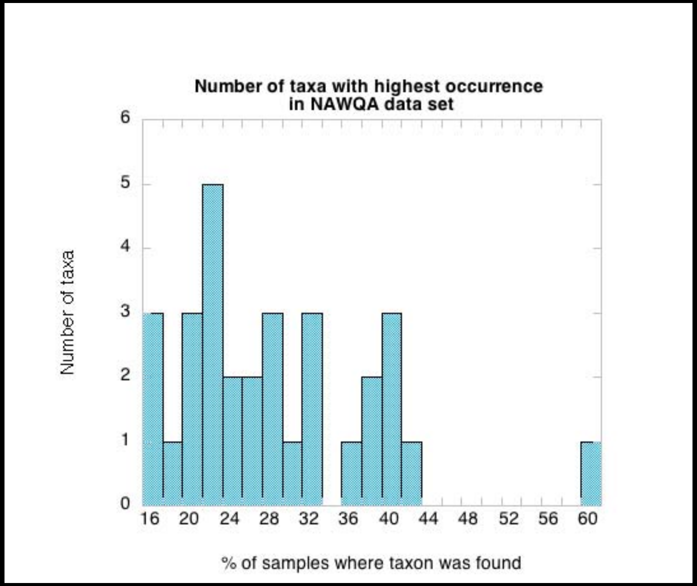
forms extensive “felts” on rock surfaces in nuisance blooms

expanding its range in Colorado, abundant in drought years for short time period



Didymosphenia geminata

Taxon name	% of samples
Achnanthidium minutissimum (Kutzing) Czarnecki	59.7
Rhoicosphenia curvata (Kutzing) Grunow ex Rabenhorst	42.6
Gomphonema parvulum (Kutzing) Kutzing	41.1
Navicula minima Grunow	41.0
Navicula cryptotenella Lange-Bertalot	39.8
Amphora pediculus (Kutzing) Grunow	39.4
Cocconeis placentula var. *euglypta* (Ehrenberg) Cleve	37.8
Nitzschia inconspicua Grunow	36.3
Nitzschia amphibia Grunow	33.2
Nitzschia palea (Kutzing) W. Smith	32.2
Encyonema minutum (Hilse in Rabenhorst) D.G. Mann	32.0
Reimeria sinuata (Gregory) Kociolek and Stoermer	31.0
Navicula gregaria Donkin	29.4
Gomphonema pumilum (Grunow) Reichard and Lange-Bertalot	29.1
Navicula capitoradiata Germain	27.5
Cocconeis placentula var. *lineata* (Ehrenberg) Van Huerck	26.8
Achnanthes lanceolata (Breb. in Kutzing) Grunow	26.4
Melosira varians Agardh	24.3
Navicula germainii Wallace	24.0
Nitzschia frustulum (Kutzing) Grunow	23.4
Nitzschia dissipata (Kutzing) Grunow	22.6
Navicula tripunctata (O.F. Muller) Bory	22.5
Staurosirella pinnata (Ehrenberg) Williams and Round	22.5
Achnanthes rostrata Ostrup	22.1
Fragilaria vaucheria (Kutzing) Peterson	20.8
Nitzschia archibaldii Lange-Bertalot	19.8
Cocconeis pediculus Ehrenberg	18.1
Nitzschia palea var. debilis (Kutzing) Grunow	17.0
Cymbella affinis Kutzing	16.8
Synedra ulna (Nitzsche) Ehrenberg	16.7



Diatom taxa with highest occurrence in National Water Quality Assessment (NAWQA) data set. From: Potapova and Charles 2002. Benthic diatoms in USA rivers: distributions along spatial and environmental gradients. Journal of Biogeography 29: 167-187.

Achnanthidium minutissimum

Considered to prefer low concentrations of total phosphorus in weighted averaging (WA) models:

British Columbia — 14 µg/l TP
(Reavie *et al*. 1995)

Mid-Atlantic Highlands — 17 µg/l TP
(Pan *et al*. 1996)

Rare taxa as indicators

- Rare species often confined to oligotrophic, less impacted sites
- More sensitive than abundant species
- However, counts of samples (600) are controlled by dominant species.
- Rare taxa may not significant and dropped from inclusion in metrics.

36% of diatom species rare (in 10 or fewer sites)

Over 50% of rare taxa are undescribed
Genus sp. #1

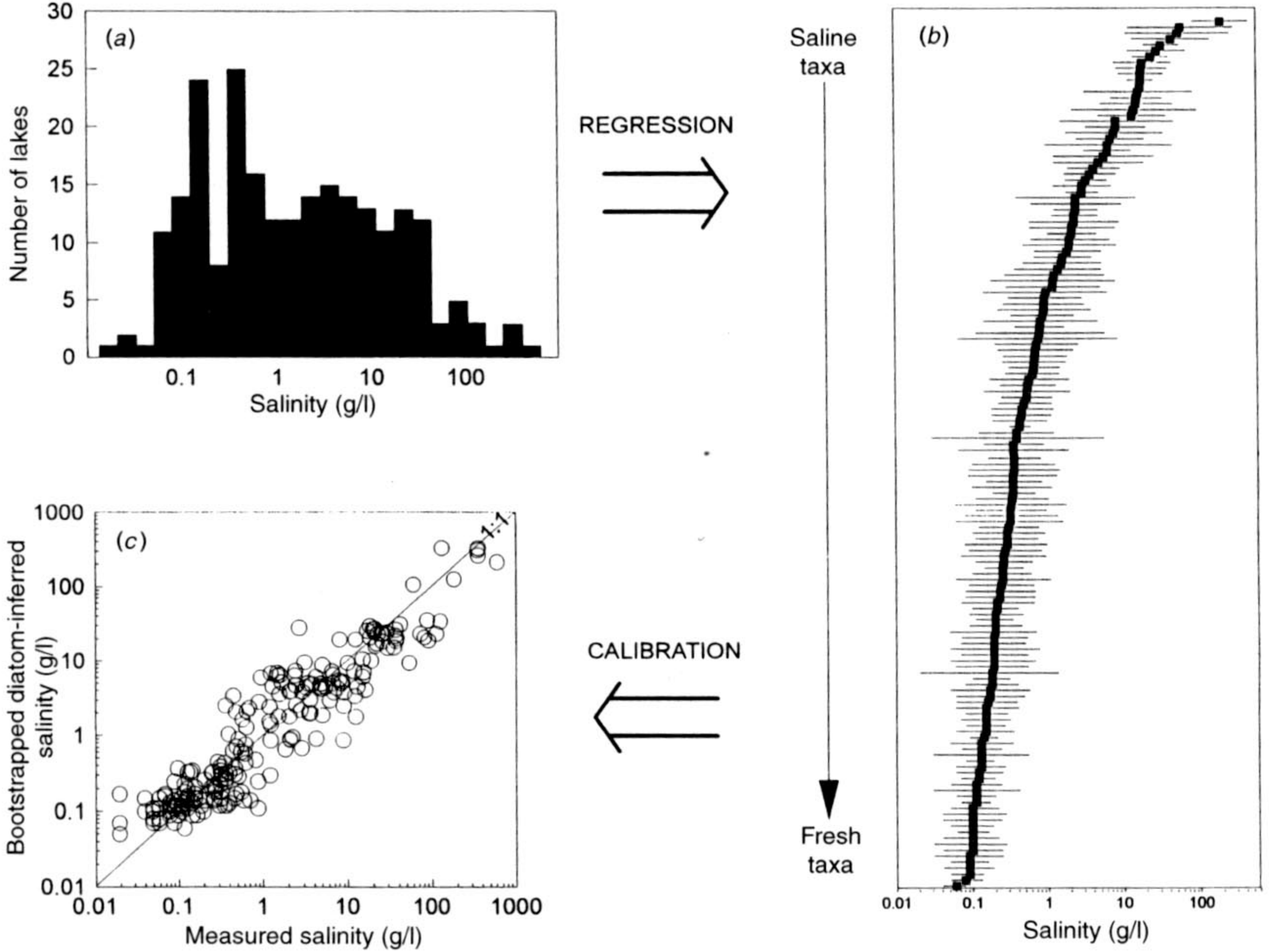
Trend of decreasing number and relative abundance of rare species along gradient of anthropogenic impact (nutrient concentration and watersheds as urban or agricultural)

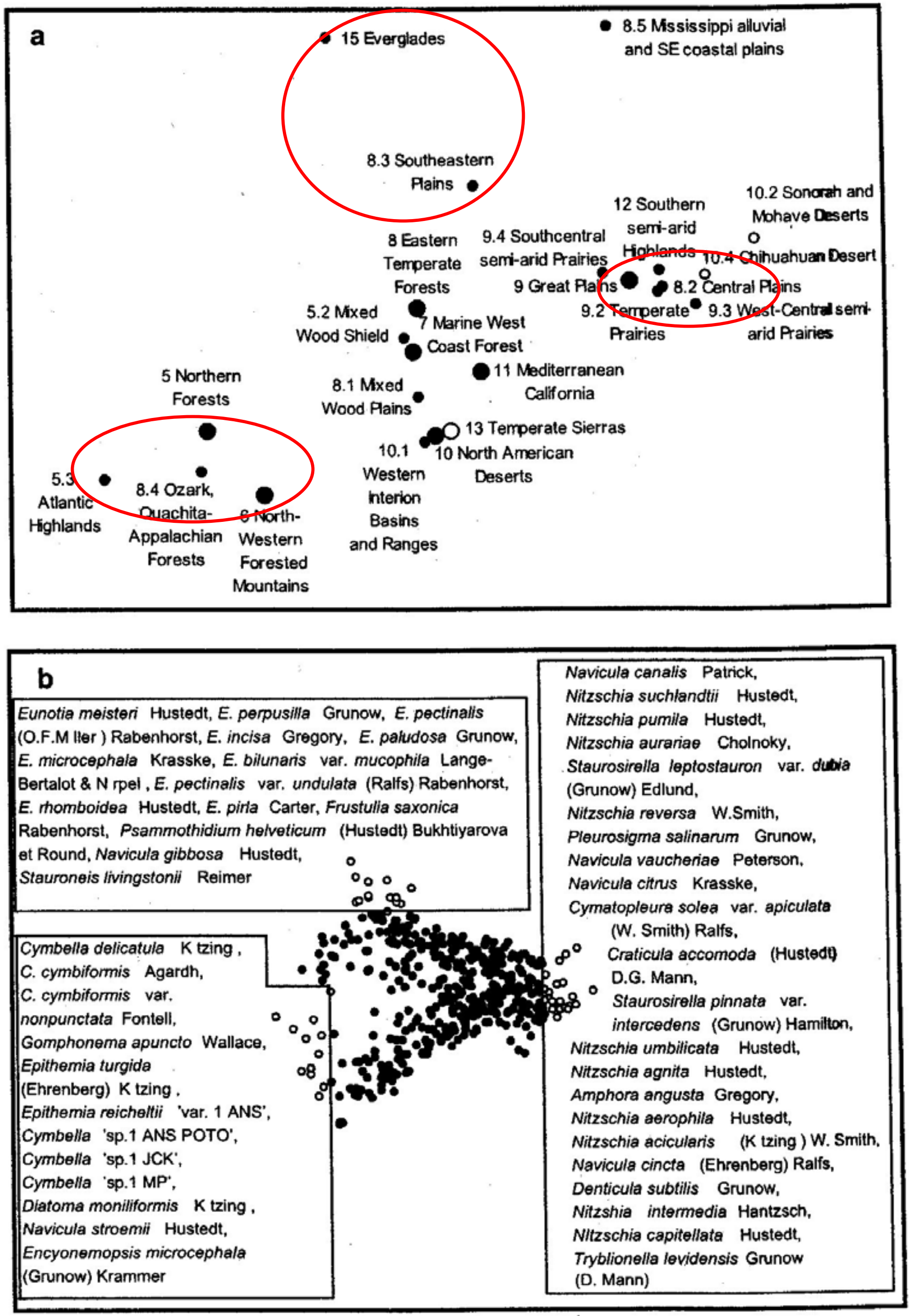
Rare diatoms in USA Rivers

Potapova & Charles (in press)

Regional differences

- Geographic distribution of species may be regional
- Ecological tolerance of species may be regional


(a)
Number of lakes
Salinity (g/l)
REGRESSION
(b)
Saline taxa
Fresh taxa
Salinity (g/l)
CALIBRATION
(c)
1:1
Bootstrapped diatom-inferred salinity (g/l)
Measured salinity (g/l)



Southeast Plains, Florida Everglades

Southwest, Central plains, West central prairies

Atlantic Highlands, Appalachia, Ozarks, Northern Forests

Detrended correspondance analysis of 2735 sample NAWQA data set A) ecoregions B) diatom taxa.

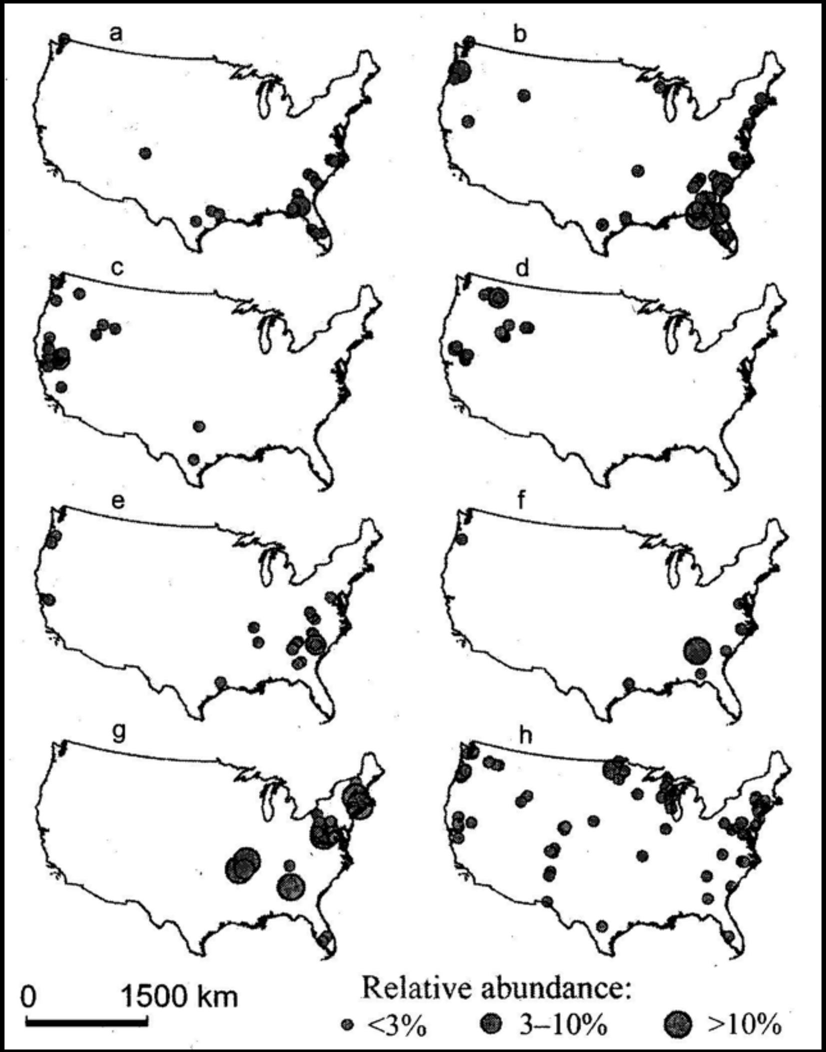
From Potapova & Charles 2002

Cocconeis fluviatilis Wallace

Synedra mazamaensis Sovereign

Navicula aikenensis Patrick

Gomphonema apuncto Wallace



Achnanthes lanceolata var. *apiculata* Patrick

Gomphoneis eriense (Grunow) Skvortzow

Navicula wallacei Reimer

Synedra parasitica (W. Smith) Hustedt

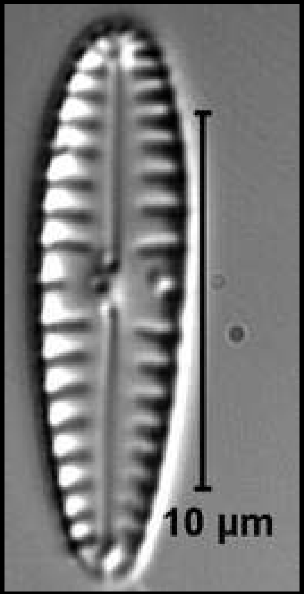
Planothidium lanceolatum

Depending on region, this taxon varies in total phosphorus tolerance in WA models:

British Columbia (Reavie *et al*. 1995)	12 μg/l TP
Mid-Atlantic Highlands (Pan *et al*. 1996)	185 μg/l TP
Illinois Rivers (Leland & Porter 2002)	210 μg/l TP

Gomphonema clevei Fricke
Reported from North American rivers (NAWQA)

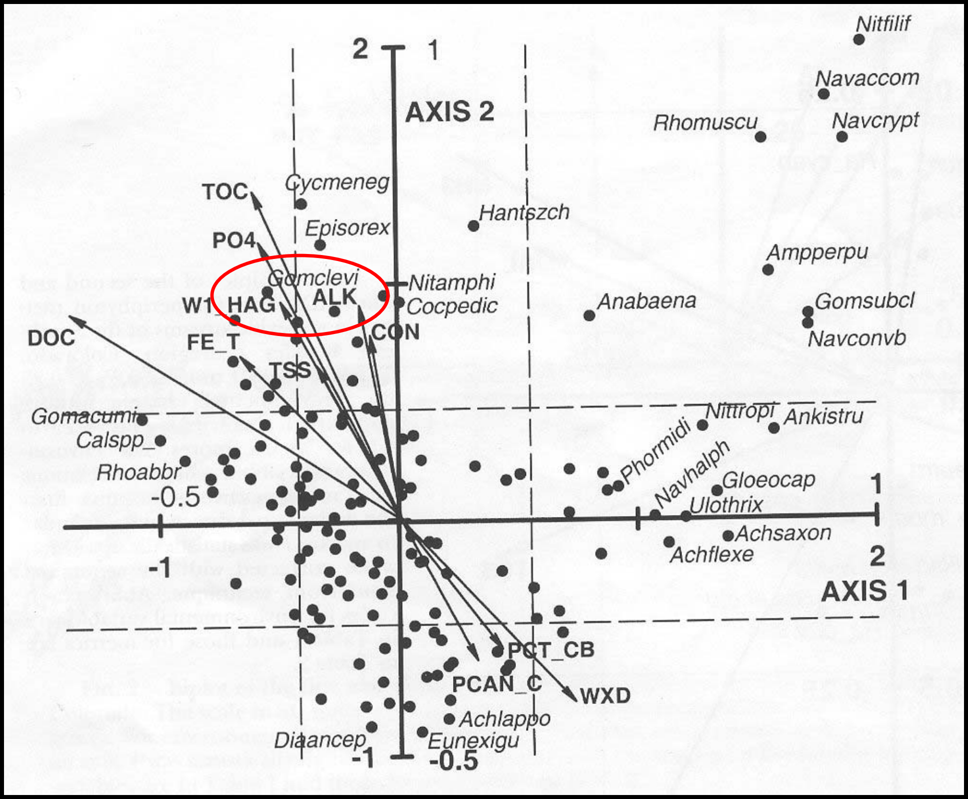
When slides were reexamined, the specimens were found not to include *G. clevei*, but two other taxa:



Gomphonema minutum Agardh

Gomphonema kobayasii Kociolek & Kingston

Described in 1999. Since then, analysts have adopted taxonomy, and *G. clevei* is no longer reported.

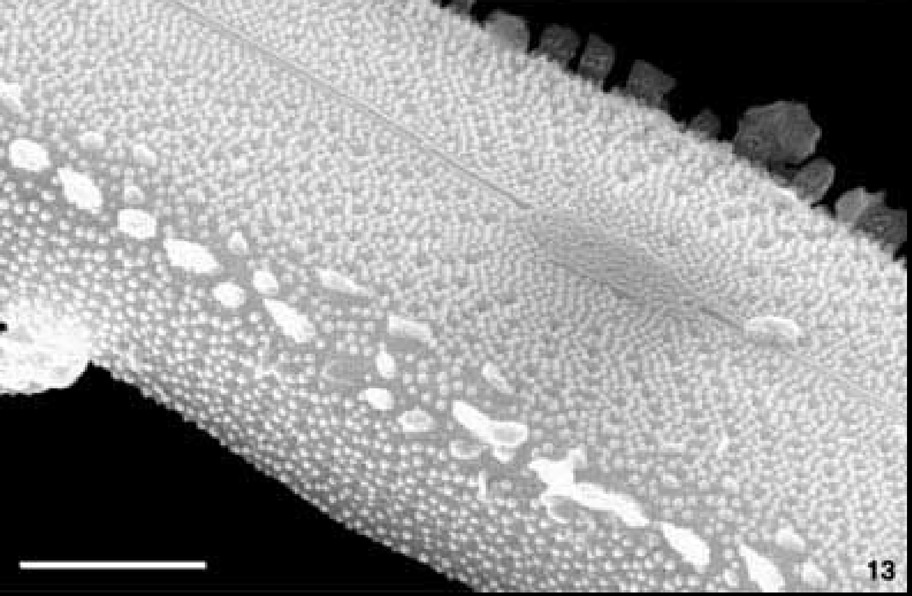


Southern Rockies REMAP

(Griffith *et al.* 2002)

Diatoms are a poorly known group of organisms

- USGS National Water Quality Program (NAWQA) reported 2735 diatom species from North America
- 26% were not identified
- That is, over 700 species were undescribed = not known to science



Unknown species

- Are often "shoe horned" into existing taxa
- Are unavailable for use in ecological assessment, because
- Species without names and ecological tolerances are dropped from analyses. In REMAP studies, appoximately 15% of diatom taxa
- No taxonomy, no autecology, no metrics

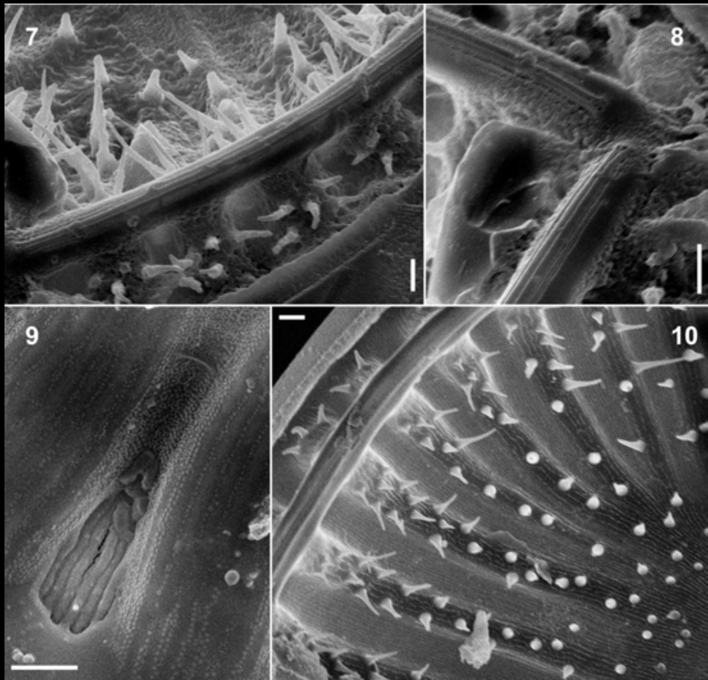
correctness

versus

consistency

Taxonomic consistency

- EMAP datasets are subject to significant problems with taxonomic inconsistency
- Permanent, publicly accessible reference collections are essential



European legacy

- North American keys are incomplete
- Taxonomic keys are based on dated European floras
  - Results in a practice of fitting the taxon to the name
  - Comparable to using "Flowering plants of Europe" to identify plants in Colorado
- European autecology (A coded checklist… the Netherlands, van Dam *et al*. 1994)

Biological analyses in EMAP

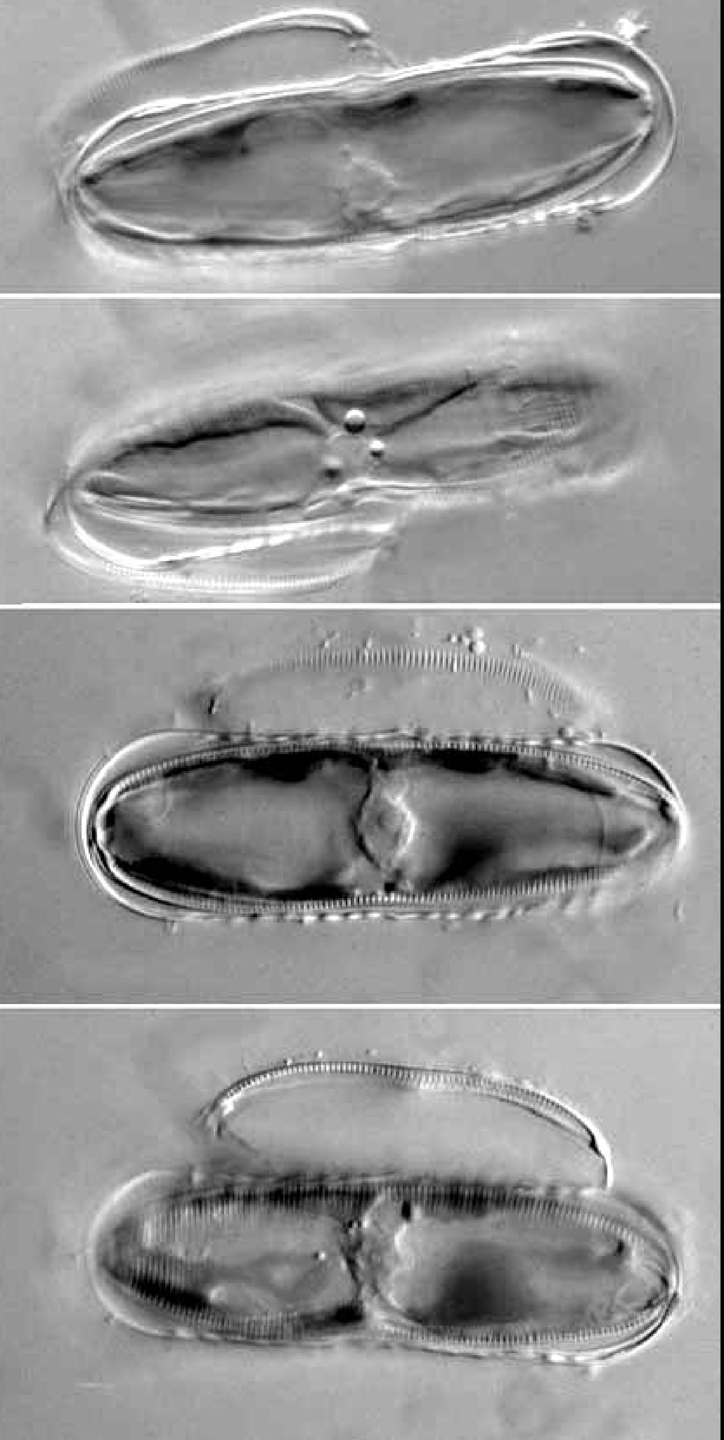
- Internal consistency in taxonomy determines the power of ecological assessment
- Design of EMAP includes a strong quality assurance for sample analysis
- Yet, in practice, a consistent taxonomy requires additional effort

Opportunity to recognize aquatic biodiversity

- New scientific discovery of biodiversity was not stated in EMAP design
- Algal samples will be useful for making ecological assessments of biological integrity
- Contribute to an understanding of diversity of diatoms and distribution across North America

Determine anthropogenic impact on diatom assemblages

- Incorporate biological information in analysis of datasets - cell size, habitat preferences, updated taxonomy
- Refine metrics to reflect regional species distributions and regional autecology using WA techniques
- Recognize rare taxa with narrow ecological ranges as indicators using stratified counting methods
- Evaluate the effects of recent (old) taxonomy?



What is next?

- Permanent, accessible archive of EMAP diatom slides
- Emphasize internal consistency over correct taxonomy
- Create more accurate, verifiable taxonomic records
- National programs ought to be utilizing consistent taxonomy
- Reveal existing biodiversity of species
- Opportunity for discovery - a North American diatom flora