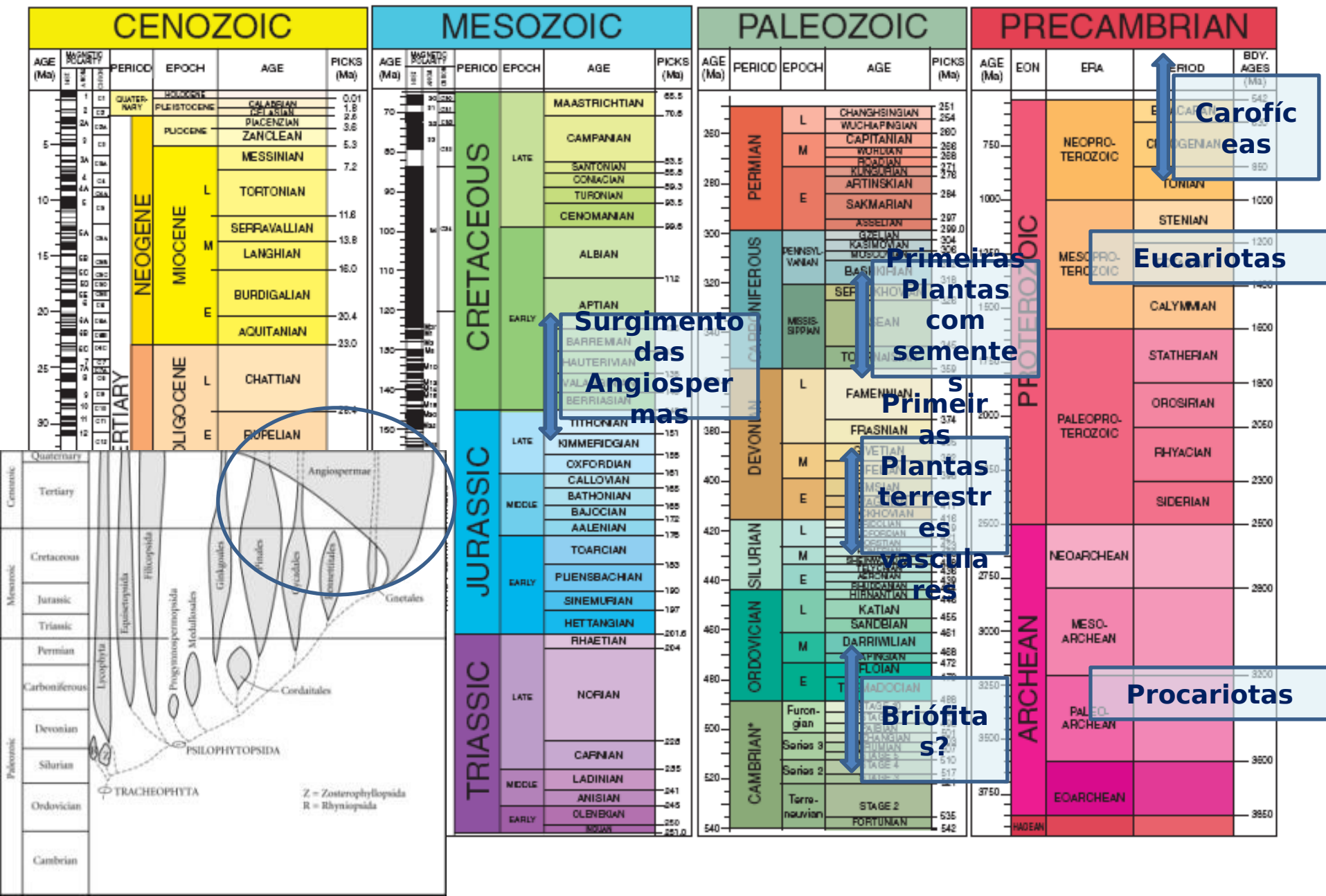


PALEOBOTÂNICA (Parte II)



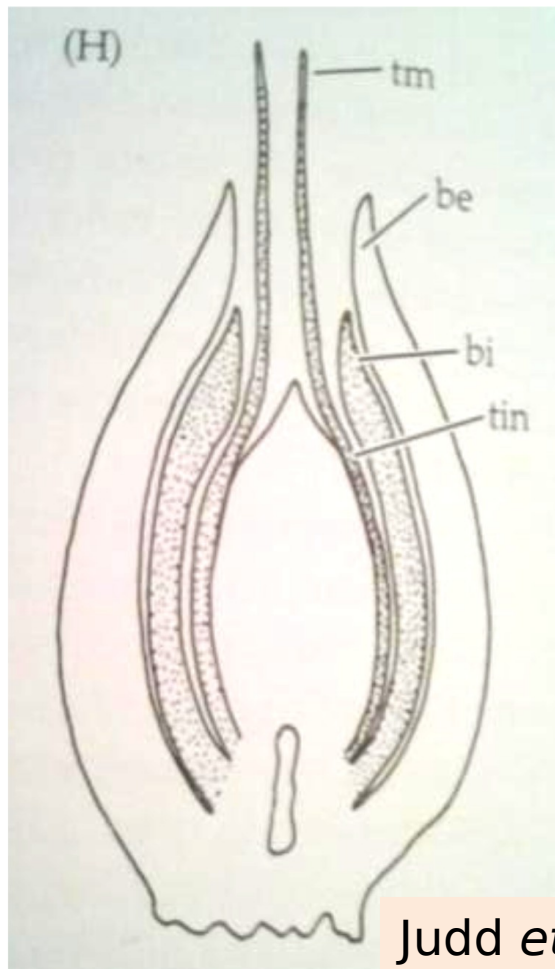
***Profa. Raquel Cassino
Universidade Federal de
Ouro Preto
Departamento de Geologia***

ANGIOSPERMAS



1. Angiospermas: características distintivas

“Gimnospermas” Estróbilos (pinhas)



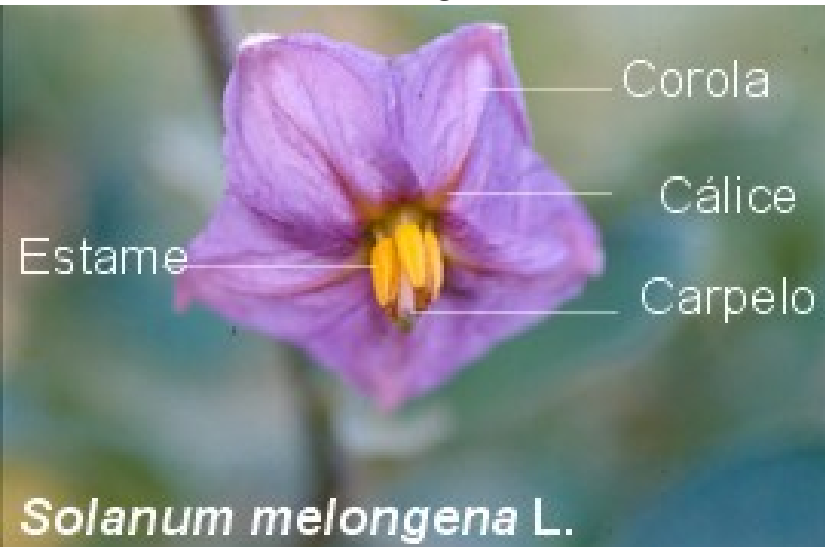
Judd et al., 2009

Angiospermas (flores verdadeiras)

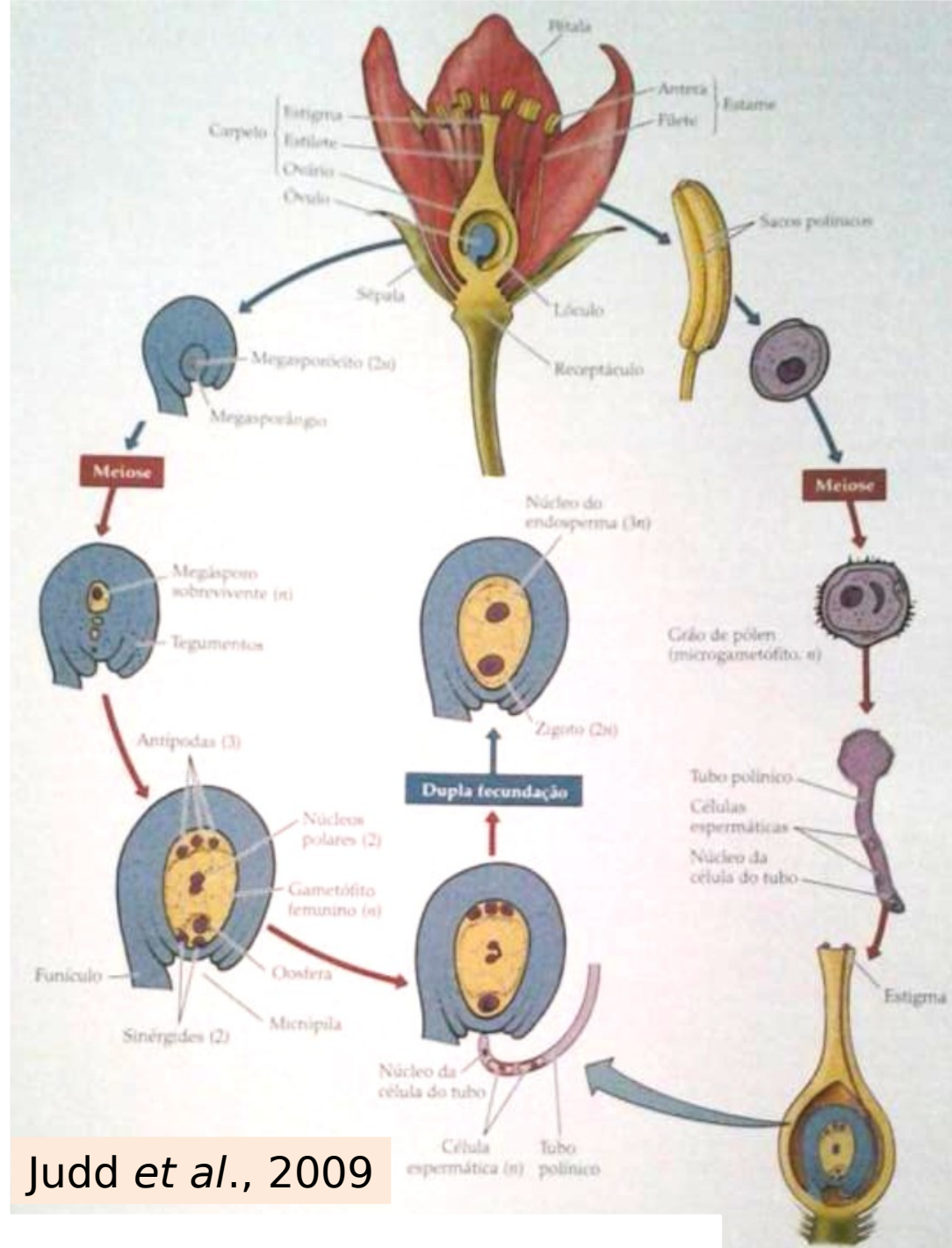
- Sementes formadas no interior de um carpelo com uma superfície estigmática para a germinação do pólen;
- Gametófitos feminino e masculino muito reduzidos;
- Estruturas reprodutivas masculinas (estames com sacos polínicos)
- Dupla fecundação com a formação de um tecido nutritivo chamado endosperma;
- Ovário se desenvolve em um fruto.

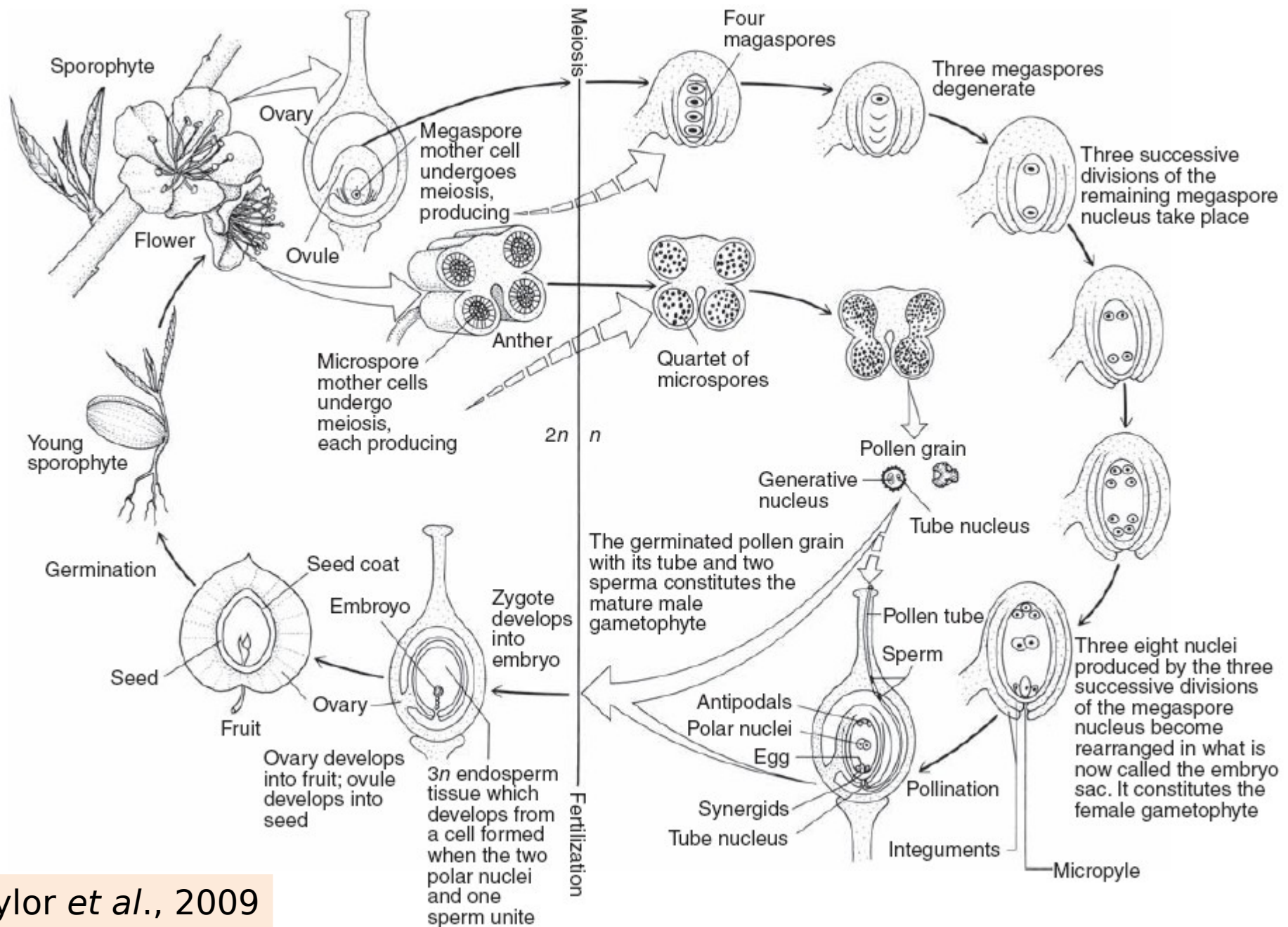


Flor



Ciclo de vida das Angiospermas

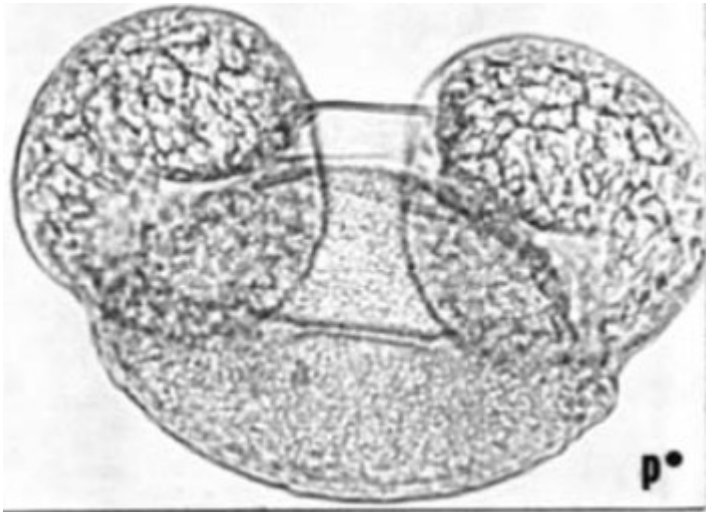




1. Angiospermas: características distintivas

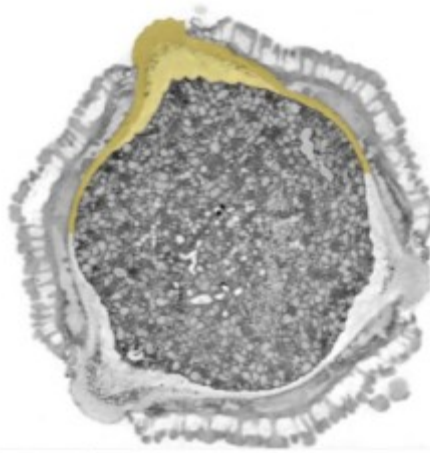
Graos de pólen

Gimnospermas

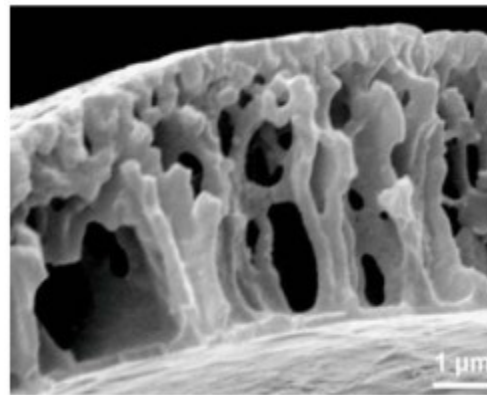


Traverse, 2007

Angiospermas



Hesse *et al.*,
2000

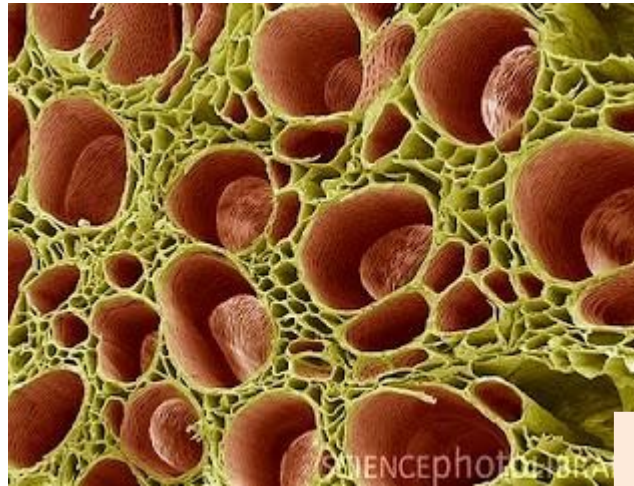
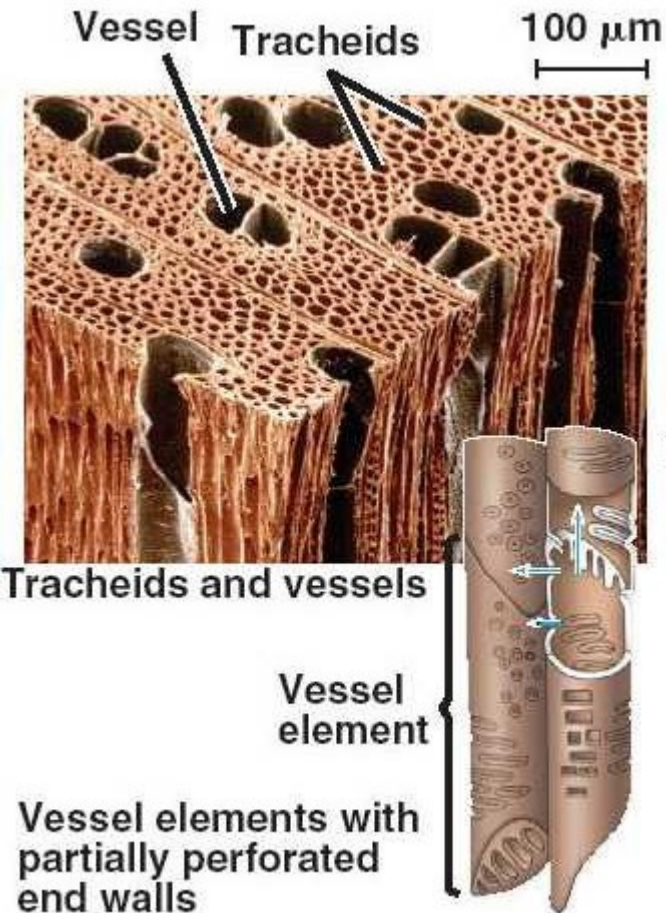


Bush & Weng, 2000

1. Angiospermas: características distintivas

Características vegetativas

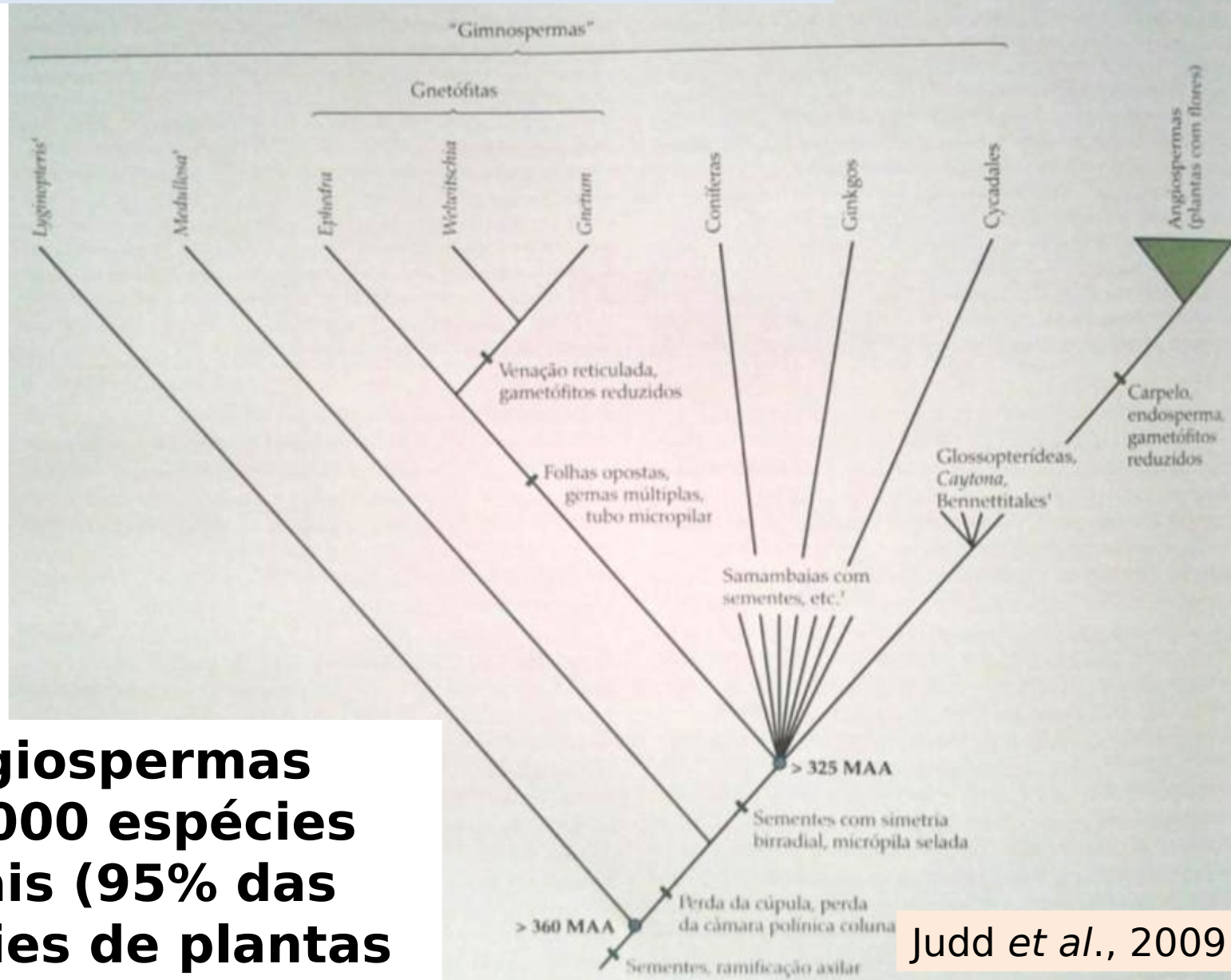
“Elementos de vaso” – células condutoras do xilema



www.sciencephoto.com



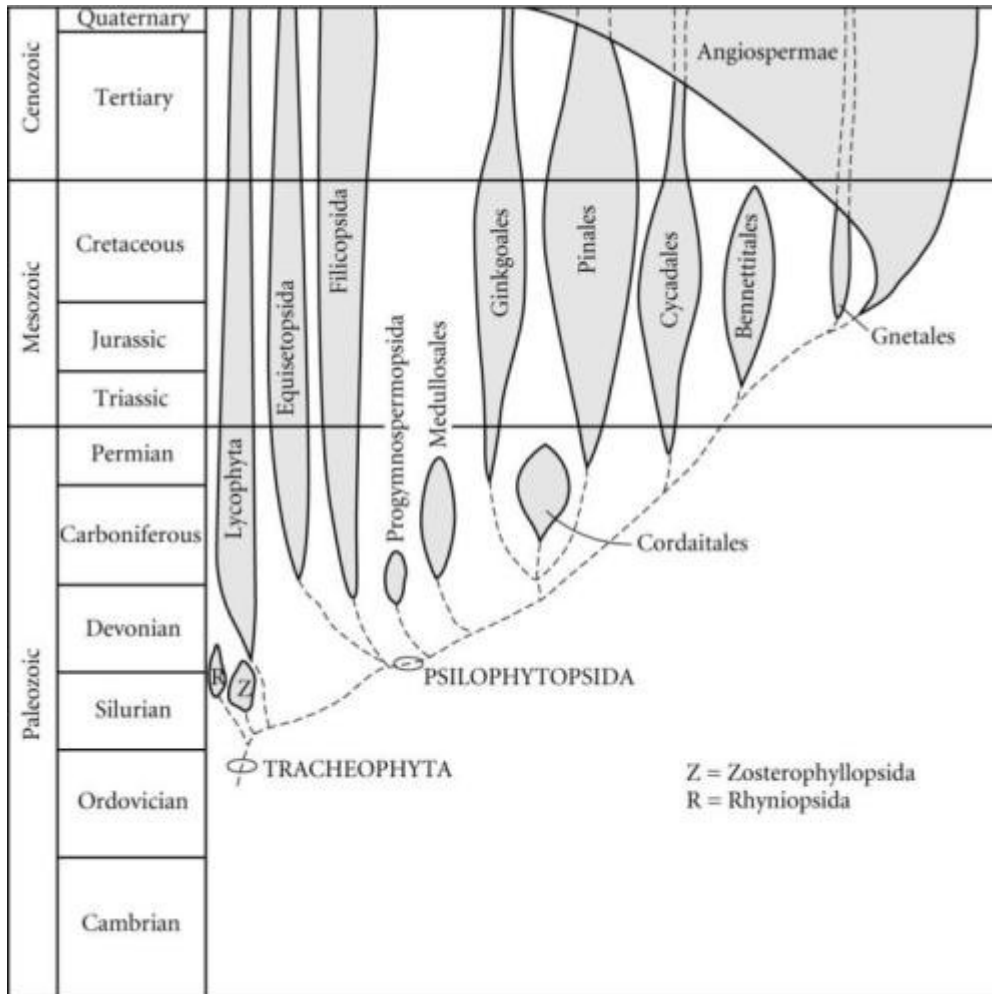
1. Angiospermas: características distintivas



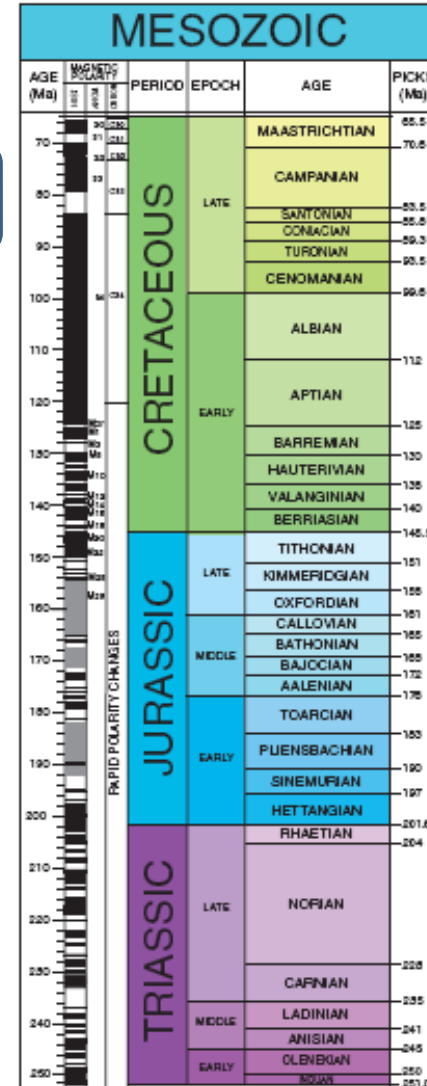
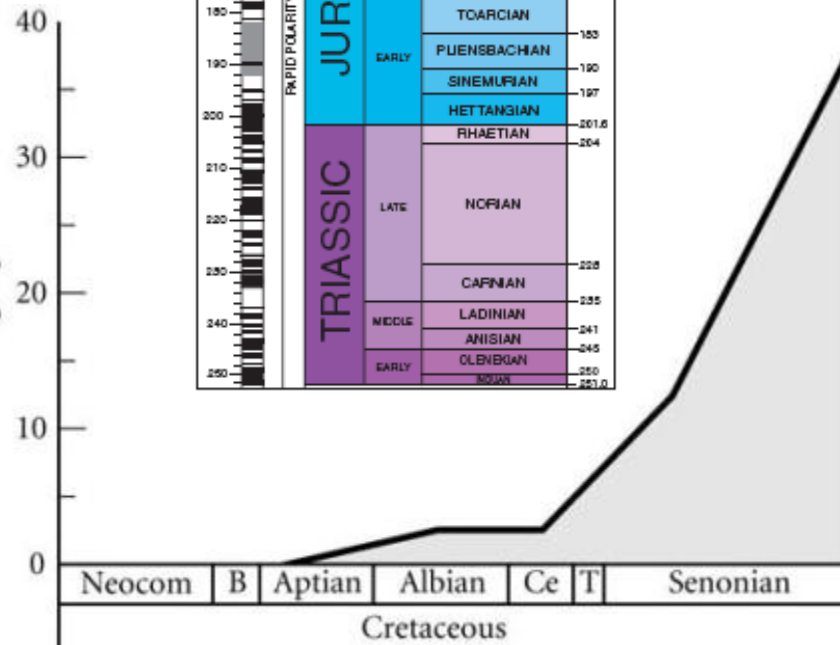
2. Surgimento das Angiospermas

- Evidências fósseis
- Evidências moleculares

Quando?
Onde?



Number of angiosperm families

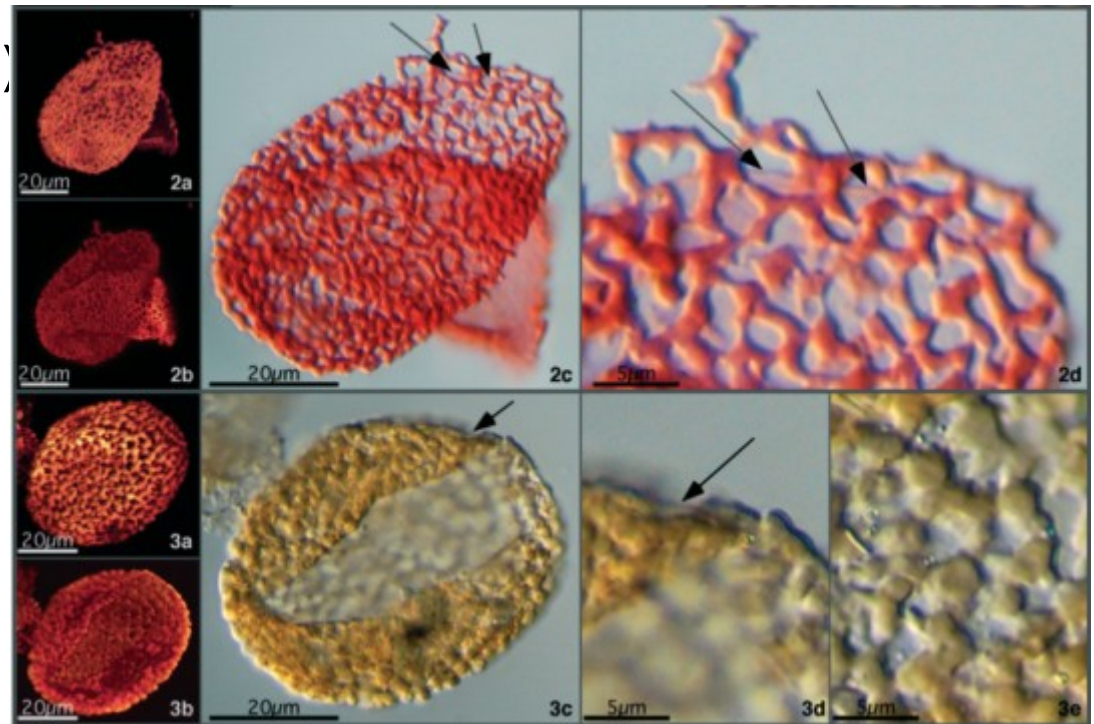


2. Surgimento das Angiospermas

1. Evidências fósseis

Fósseis “pré-Cretáceo” - Possivelmente relacionados às Angiospermas

- Grãos de pólen (Triássico)
- Macrofósseis (Triássico)
Sanmiguelia



Hochuli & Fiest-Burkhardt, 2004

3. Surgimento das Angiospermas

***Sanmiguelia* (Triássico)**



1cm

Taylor et al., 2009

3. Surgimento das Angiospermas

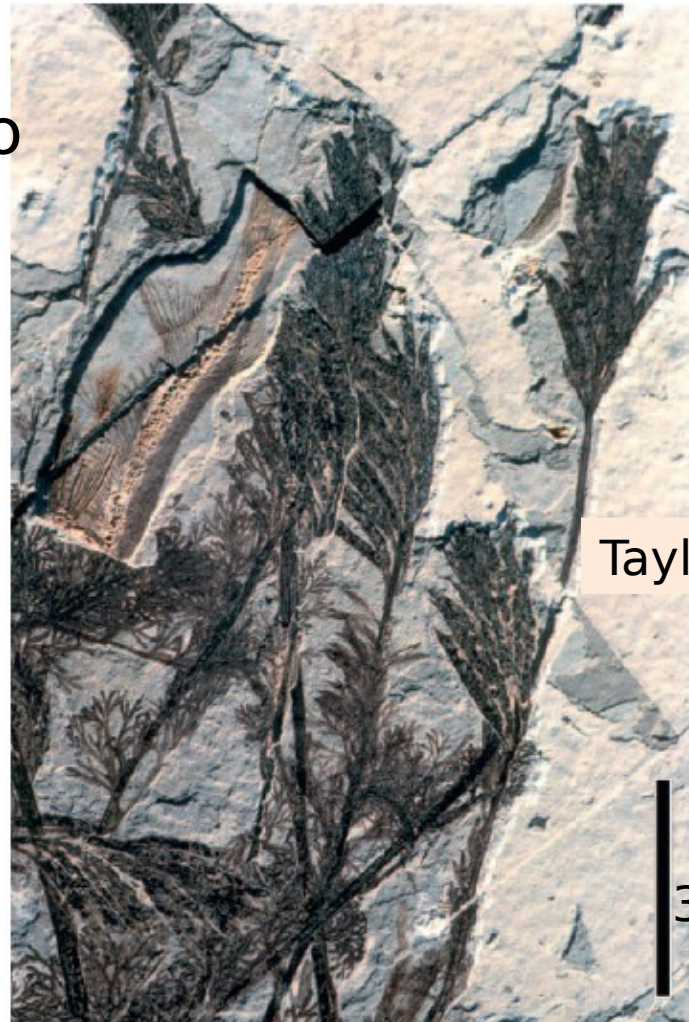
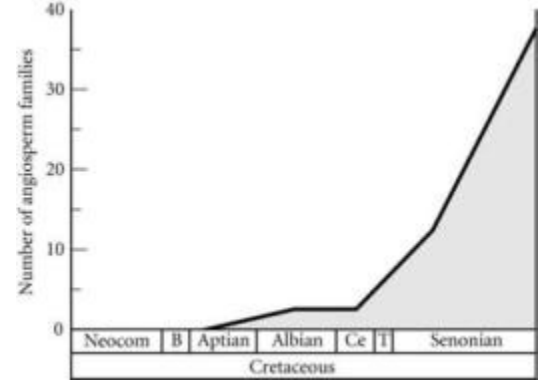
1. Evidências fósseis

Fósseis do Cretáceo - Aceitos como fósseis mais antigos de Angiospermas

Gênero *Archaeofructus*
Cretáceo - Barremiano-Aptiano
China



Taylor et al., 2009



Taylor et al., 2009

3,5cm

2. Surgimento das Angiospermas



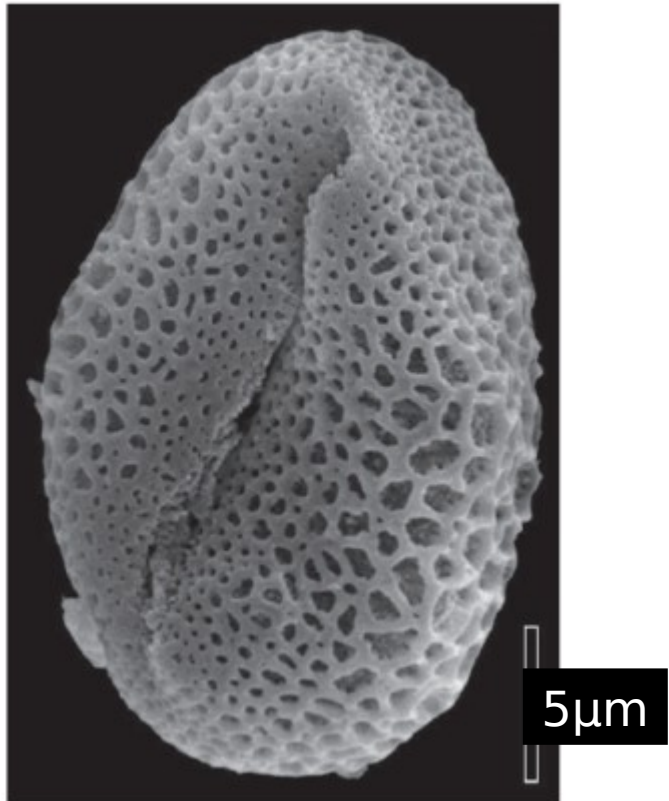
Archaeofructus liaoningensis



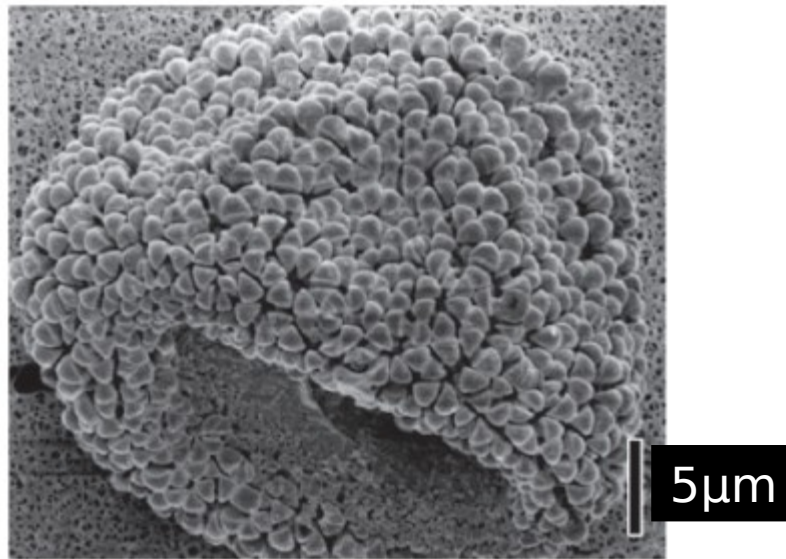
Archaeofructus eoflora

2. Surgimento das Angiospermas

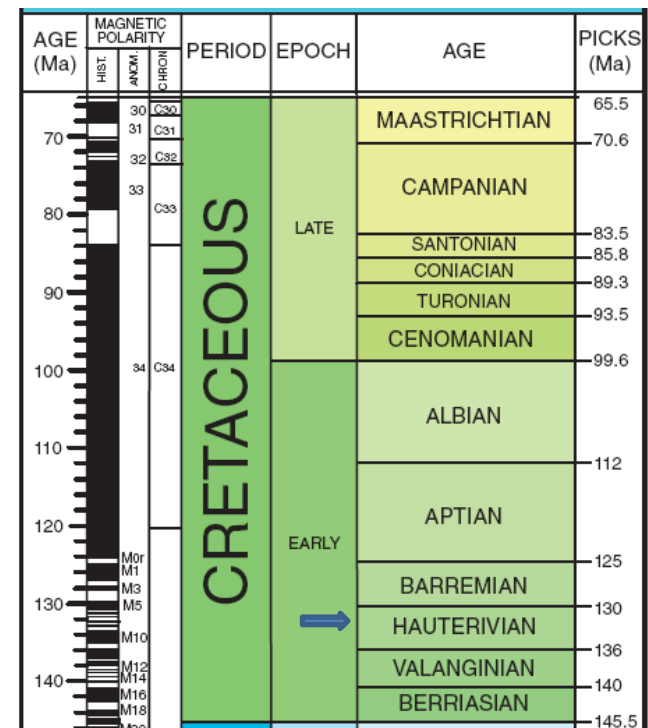
Grãos de pólen de Angiospermas mais antigos (Cretáceo)



Retimonocolpites

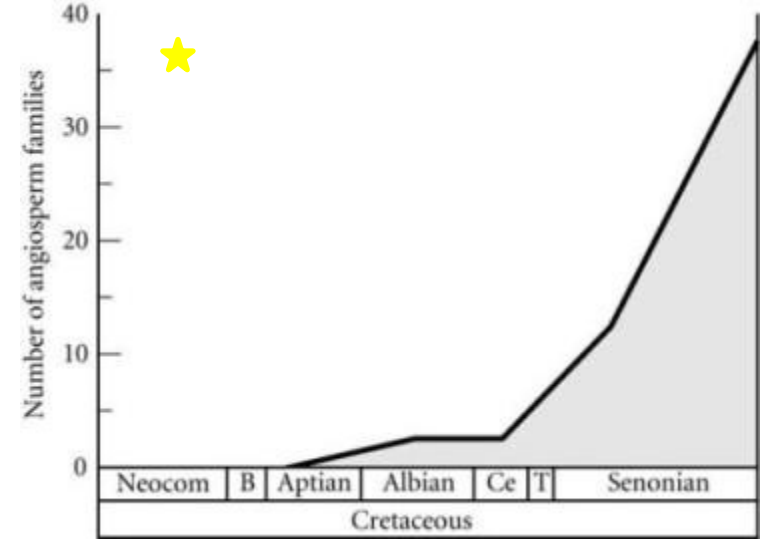
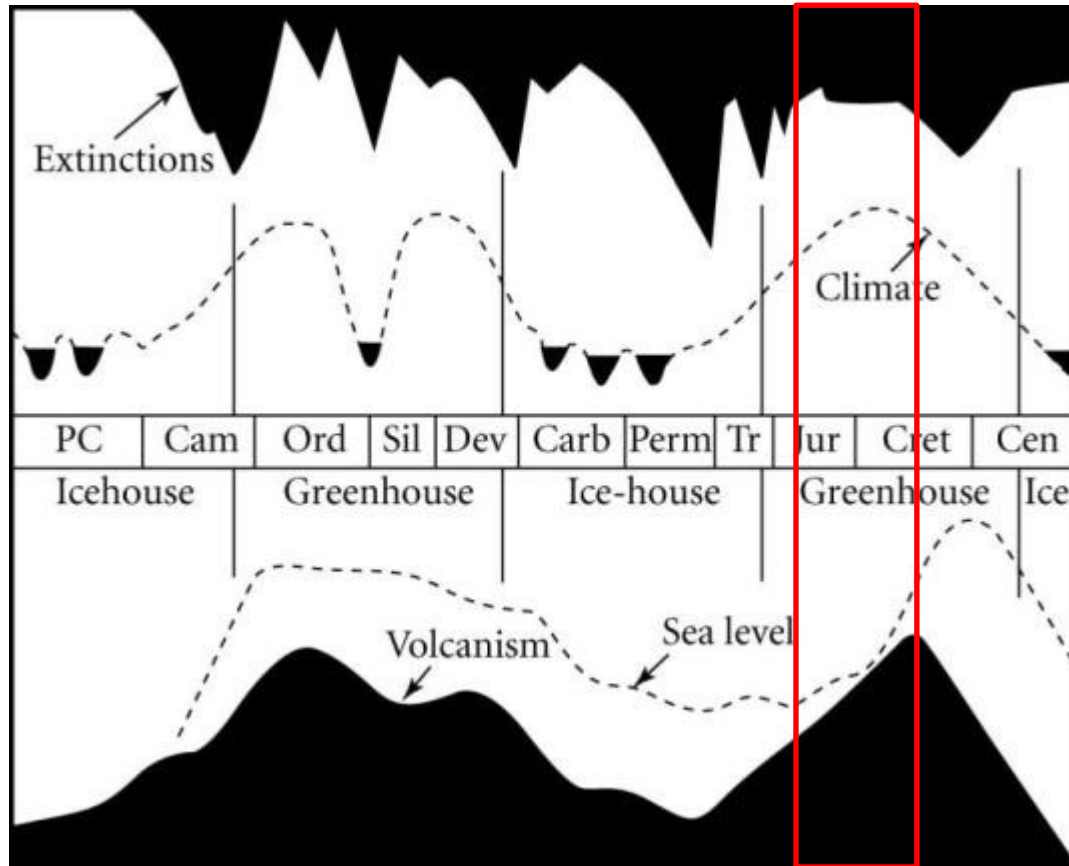


Stellatopollis



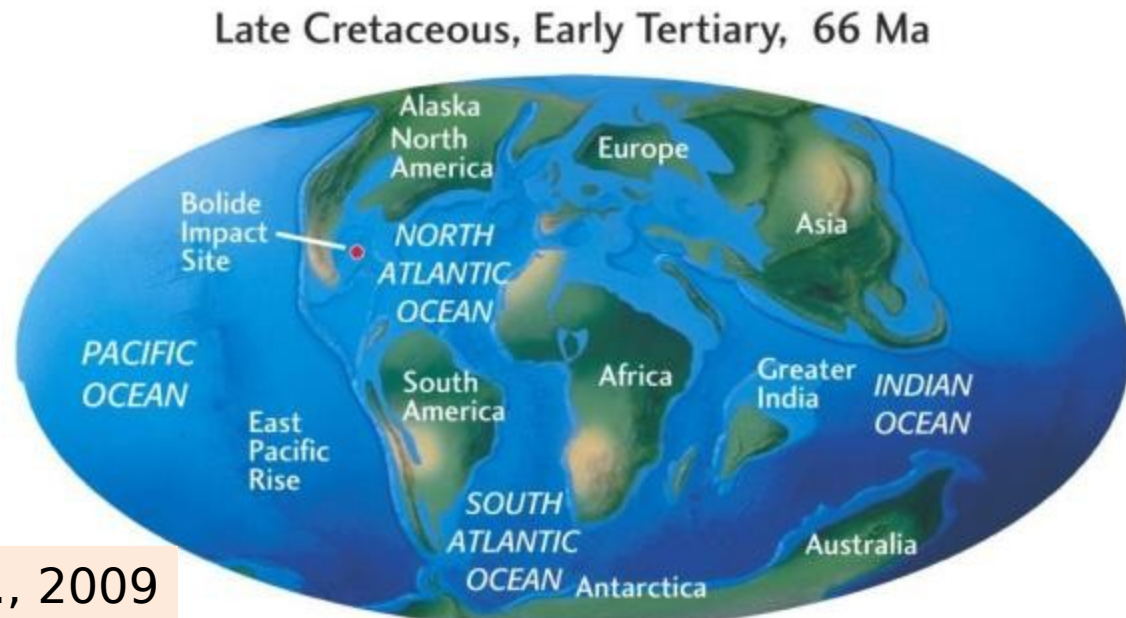
2. Surgimento das Angiospermas

Fatores ambientais e paleogeografia no Cretáceo



2. Surgimento das Angiospermas

Fatores ambientais e paleogeografia no Cretáceo



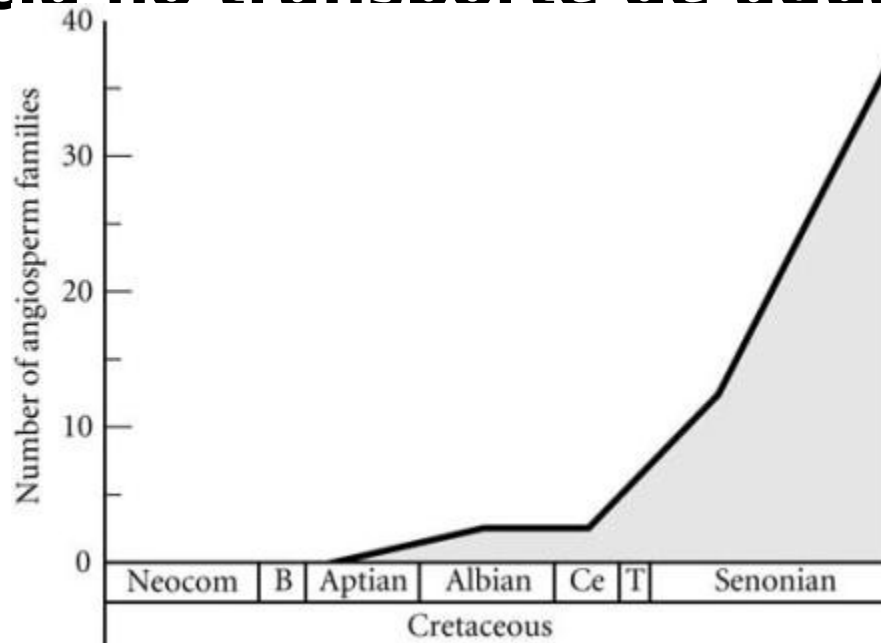
Press *et al.*, 2009

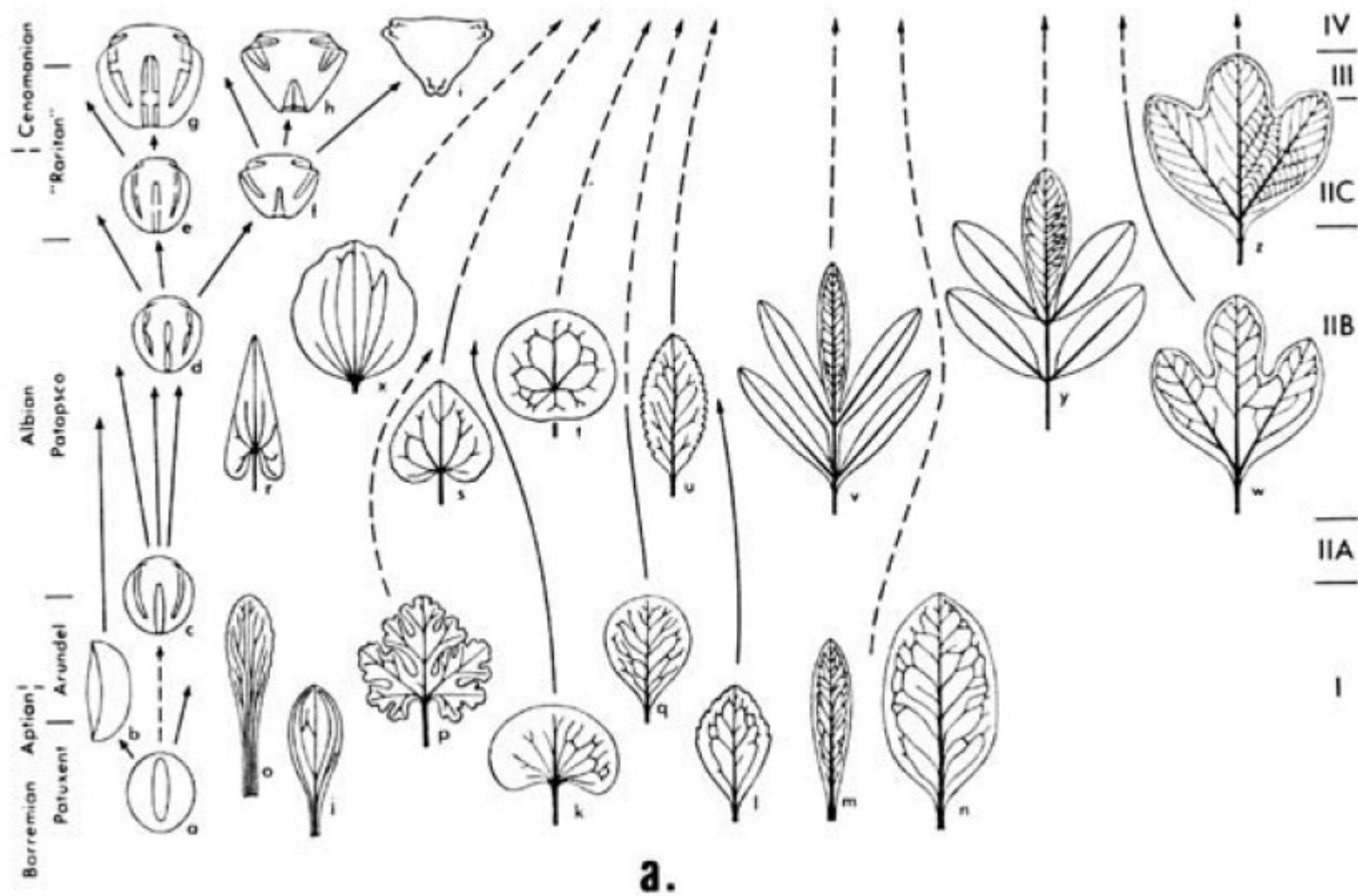
3. Radiação das Angiospermas

→ diminuição / destruição da vegetação dominante

Angiospermas (inicialmente adaptadas a ambientes alterados?)

- **Ciclo de vida curto**
- **Taxas de especiação elevadas**
- **Eficiência no transporte de água**





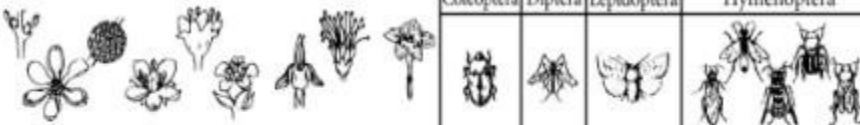
Diversidade de insetos

Labandeira *et al.*, 2001

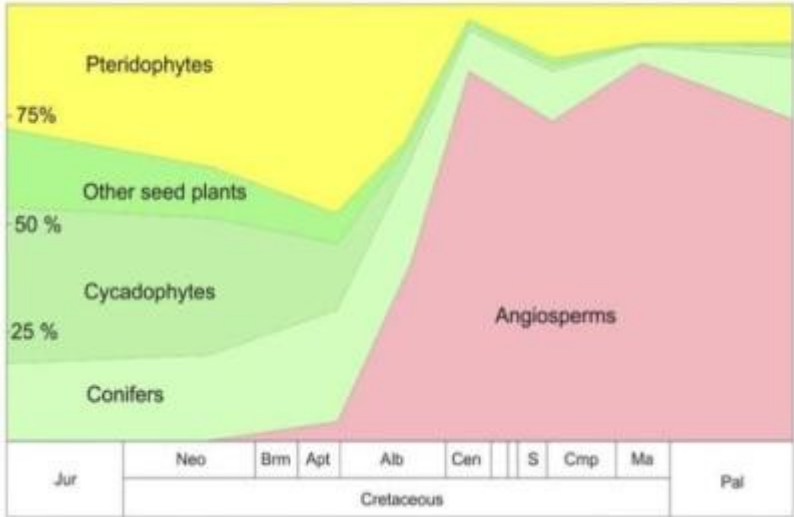
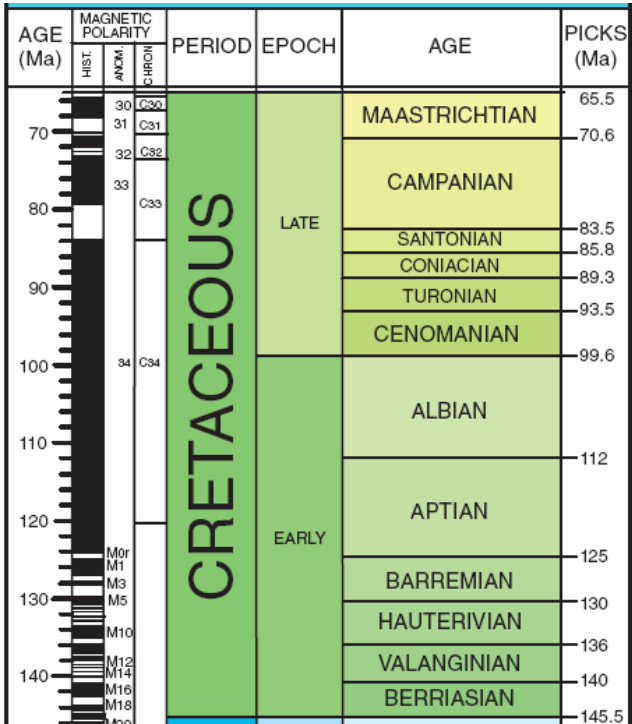
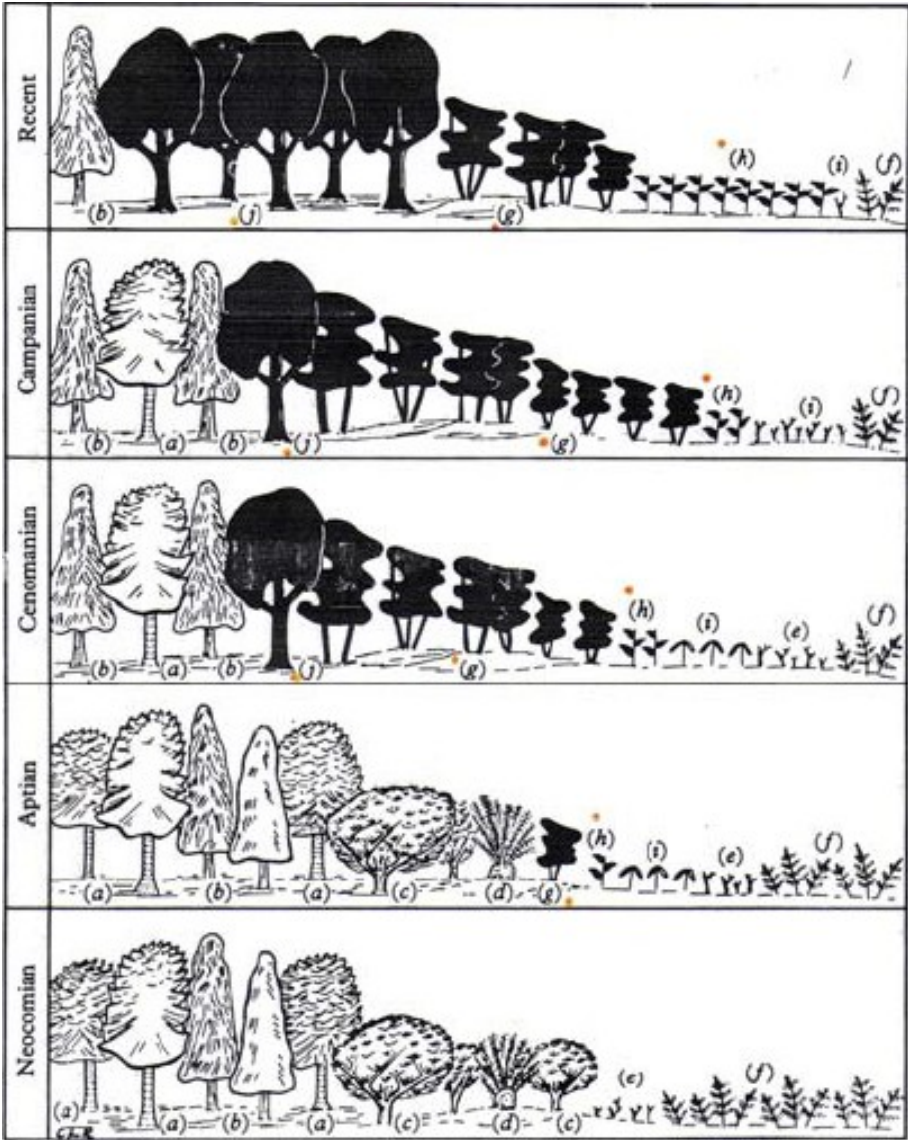


Co-evolução

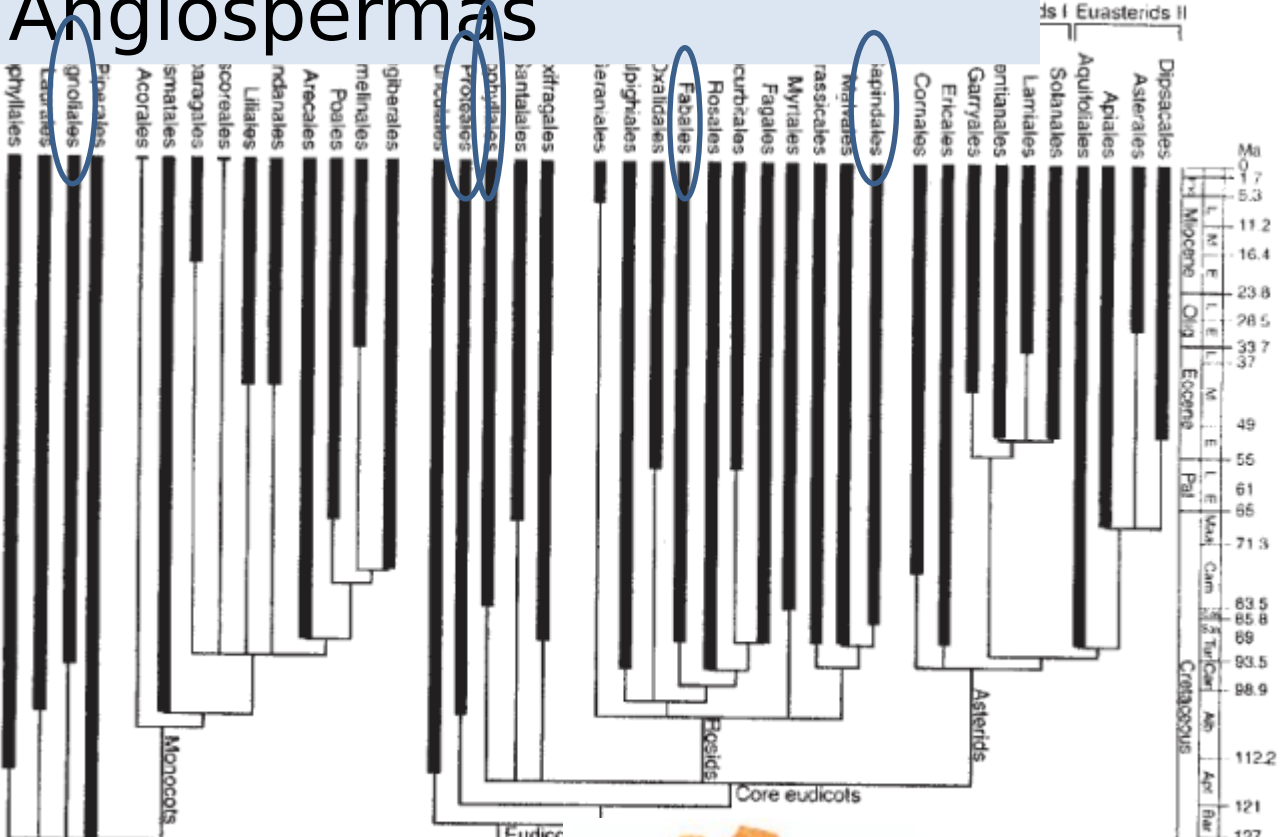
Benton & Harper, 200

											Coleoptera	Diptera	Lepidoptera	Hymenoptera				
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)
Early Tertiary	Eocene																	
	Paleocene																	
Late Cretaceous	Maastrichtian																	
	Campanian																	
	Santonian																	
	Coniacian																	
	Turonian																	
	Cenomanian																	
	Albian																	
Early	Aptian																	
	Barremian																	

3. Radiação das Angiospermas

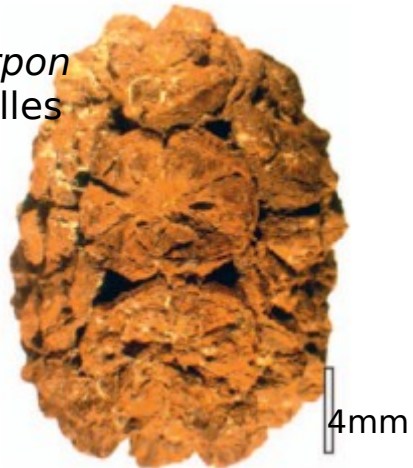
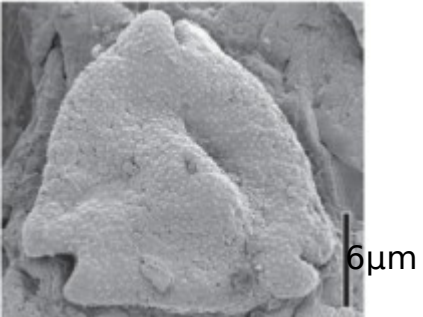


3. Radiação das Angiospermas

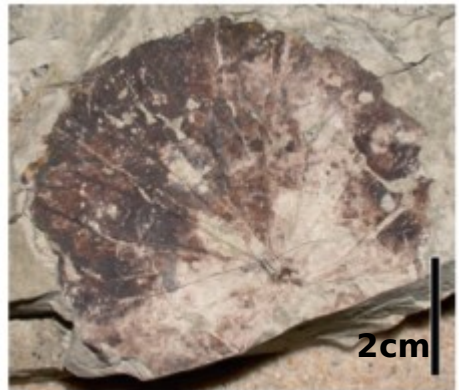


Caryanthus
Fabales

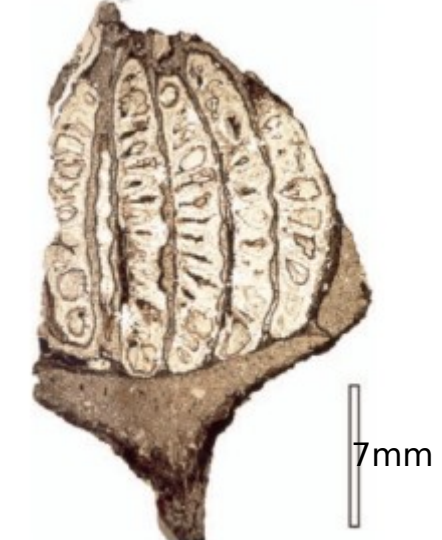
Coahuilacarpus
Caryophyllales



Acerites
Sapindales



Nelumbo puertae
Proteales



Protomonimia kasai-nakajhongii

Ocorrências fossilíferas no Brasil

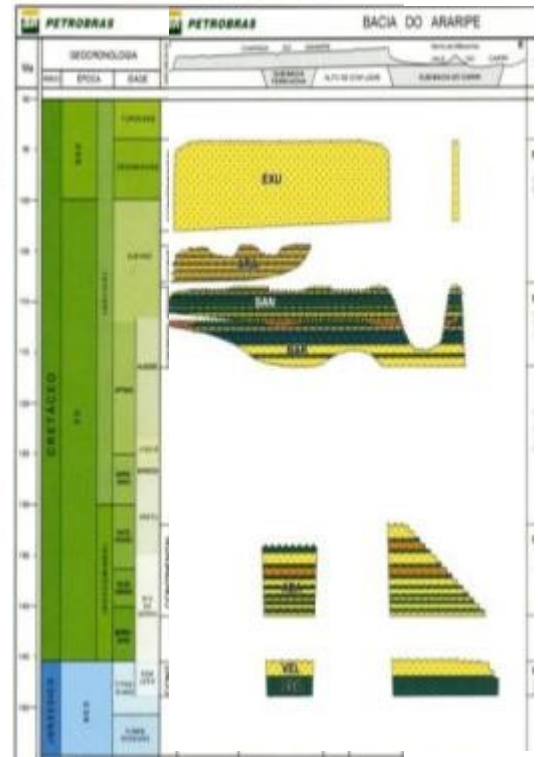
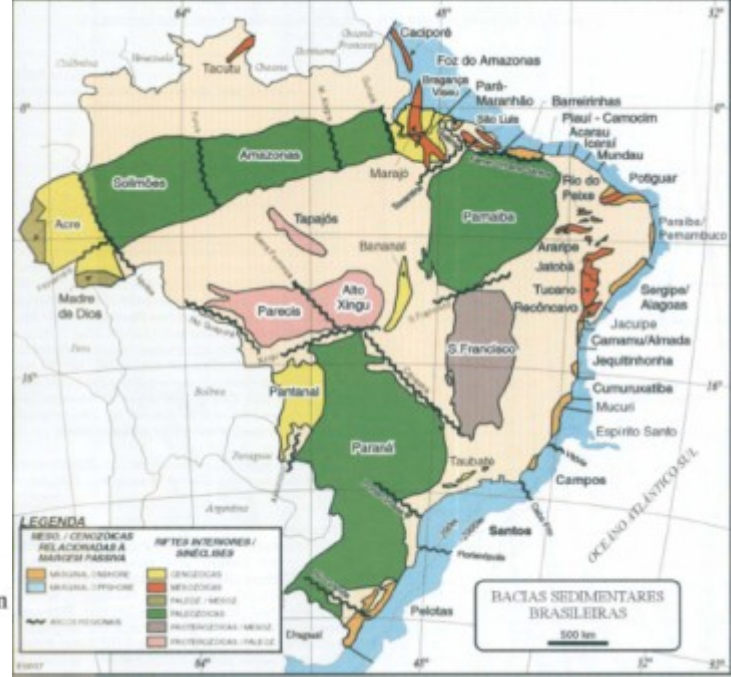
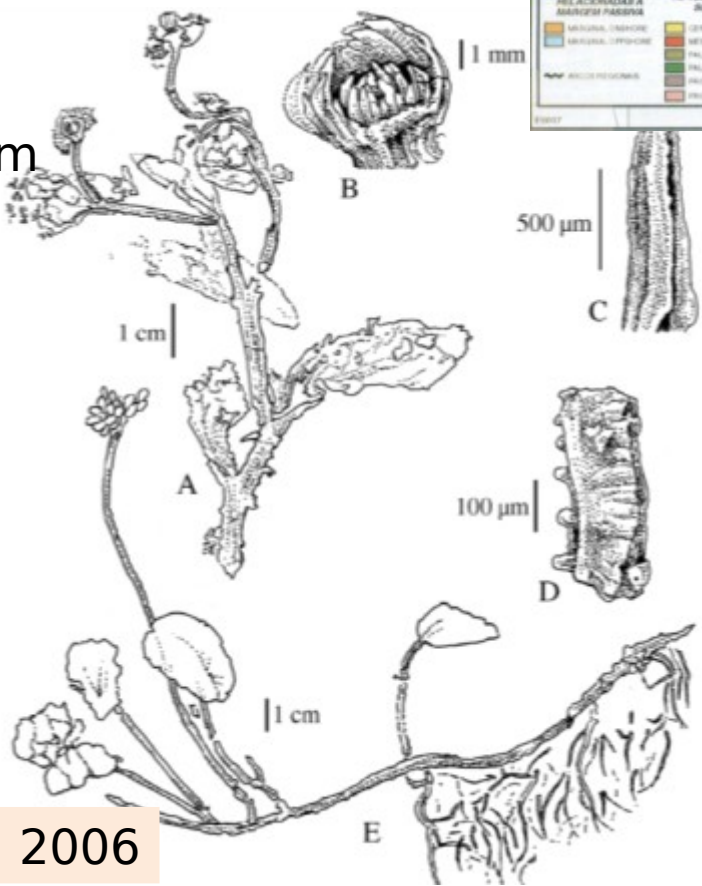


*Endressinia
brasiliana*

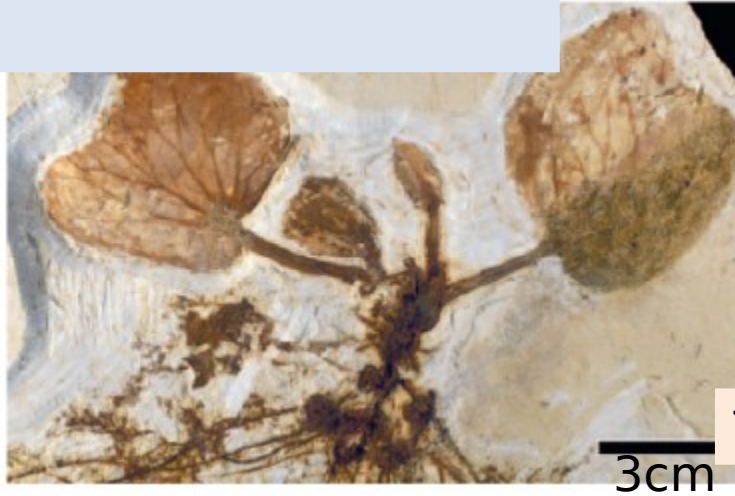
Taylor et al., 2009

**Membro Crato
Formação
Santana**

Friis et al., 2006



Ocorrências fossilíferas no Brasil



Taylor et al., 2009

Bacias interiores - Paleógeno / Neógeno



Flor fóssil

Caesalpinia echinataformis



Paleopalynologia

Palinomorfo S

Palinomorfos

- **Microfósseis (5 a 500µm)**
- **Composição orgânica (esporopolenina, quitina)**

Tipos de Palinomorfos

Acritarc
OS

Proterozóico - Recente



acritarcos – Mais antigos palinomorfos

Traverse, 2007

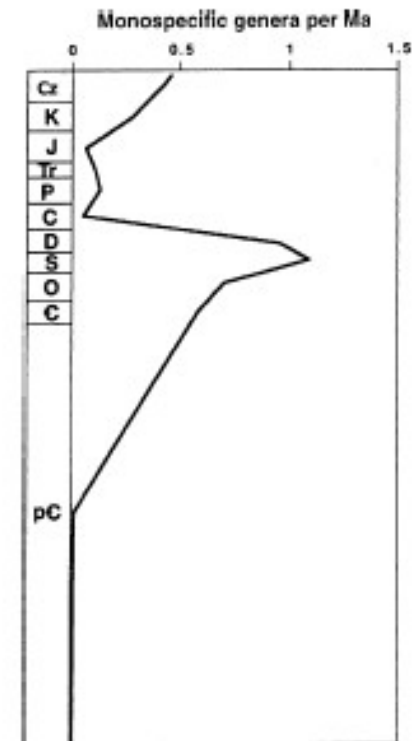
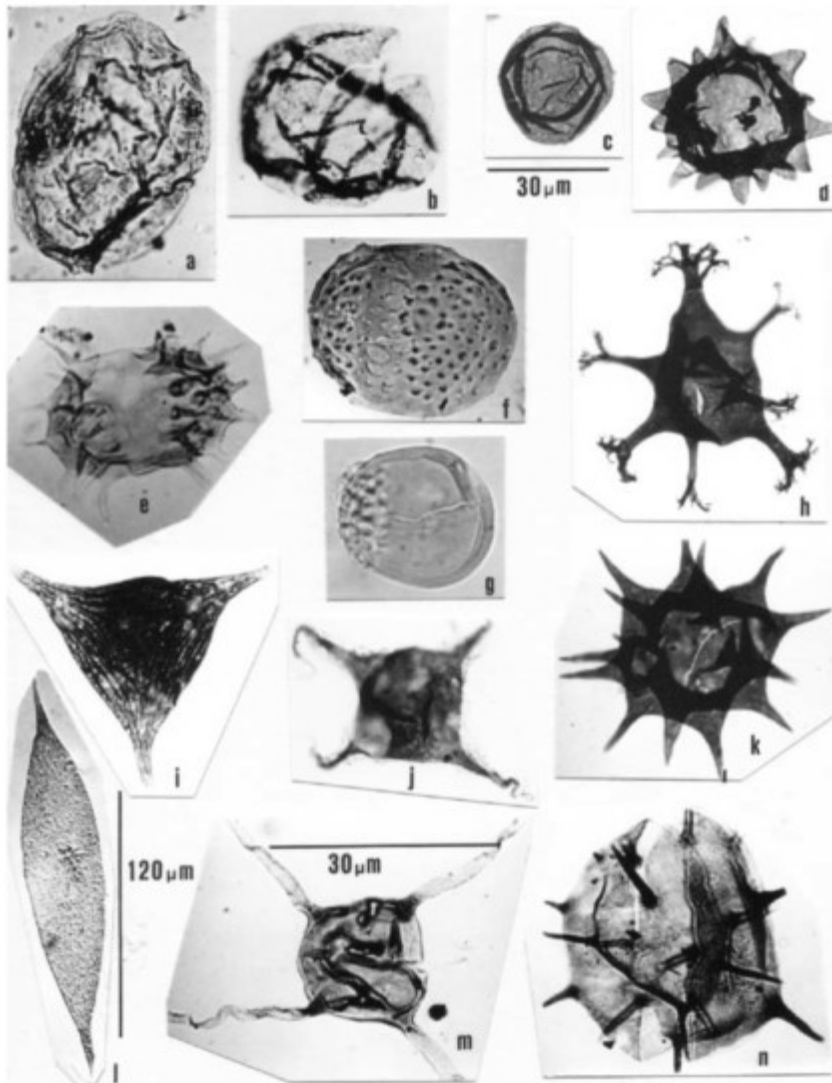
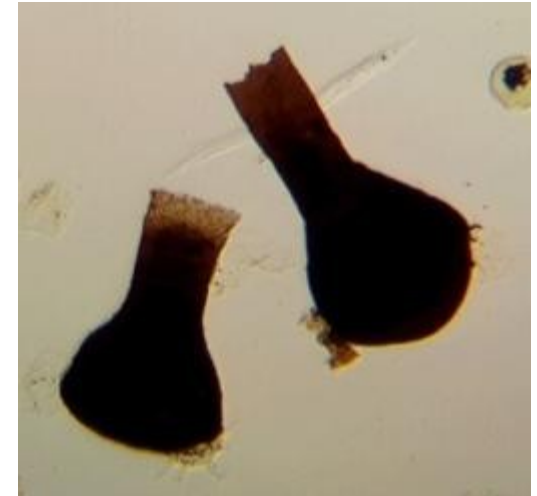
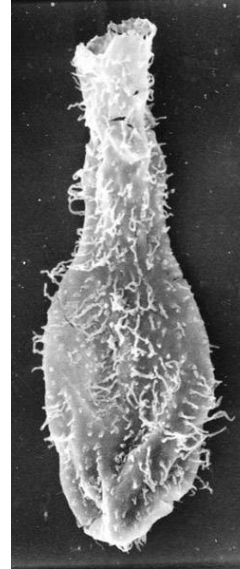
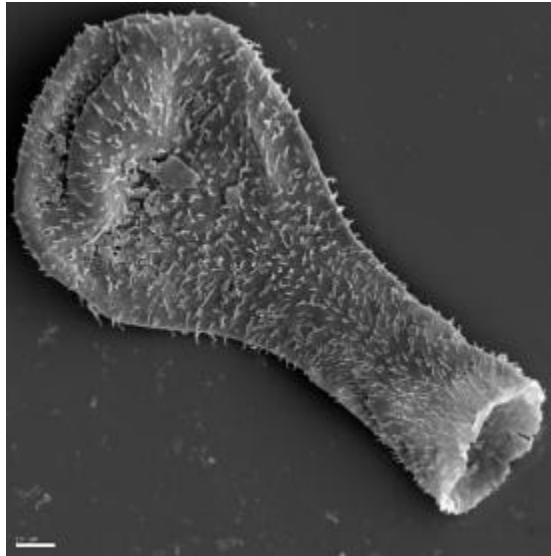
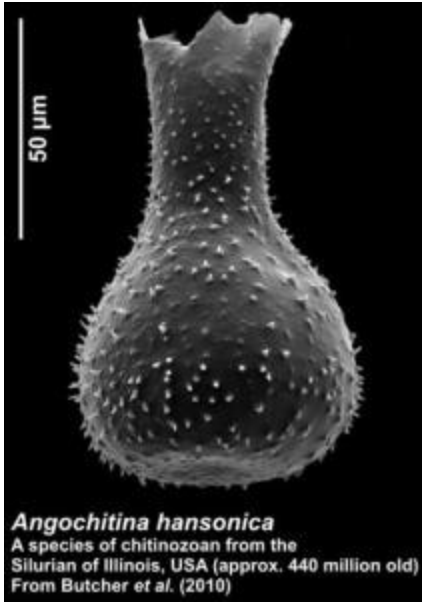


Figure 6.2 Acritarch species diversity from Proterozoic (Late Precambrian) to Cenozoic (Cz). Letters on the left refer to geologic eras and periods Precambrian through Cenozoic. The curve expresses species per Ma plotted per period of time. The latest Devonian acritarch crash is very obvious. Modified from Strother, 1996.

Quitinozoári

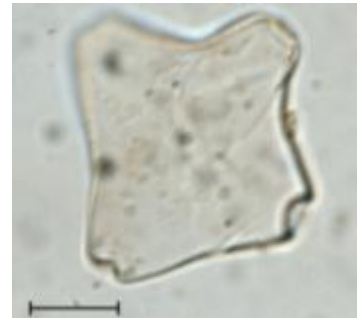
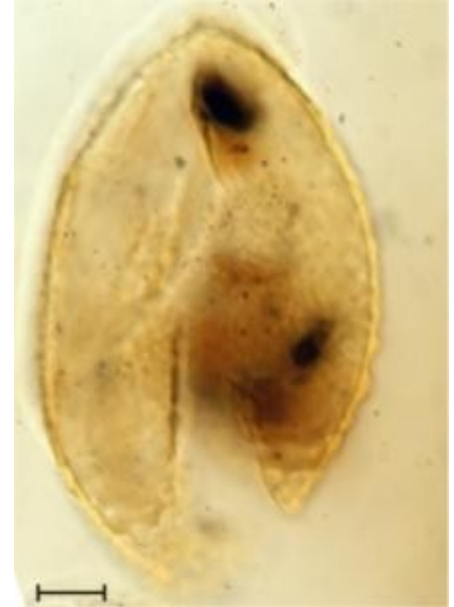
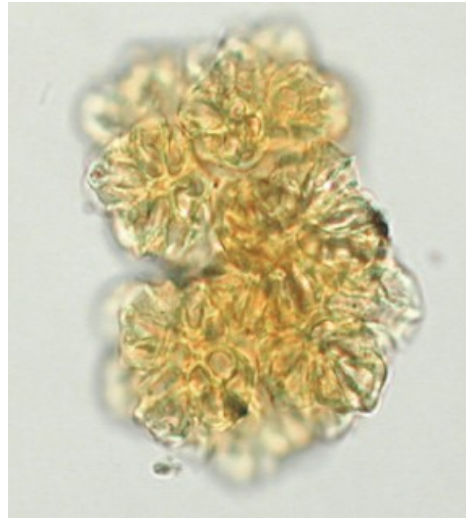
os

Cambriano Superior – Devoniano Superior



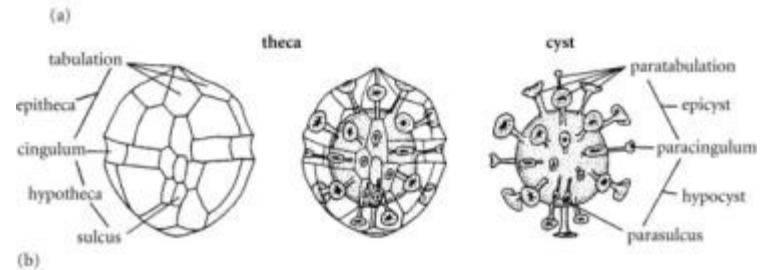
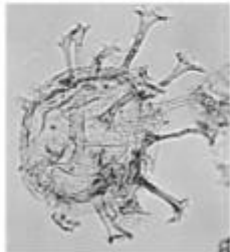
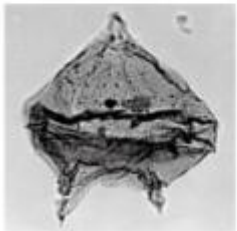
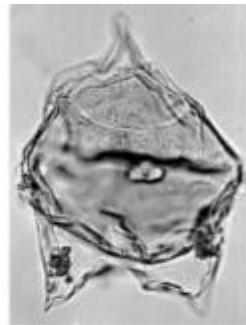
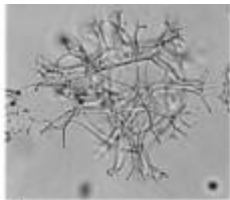
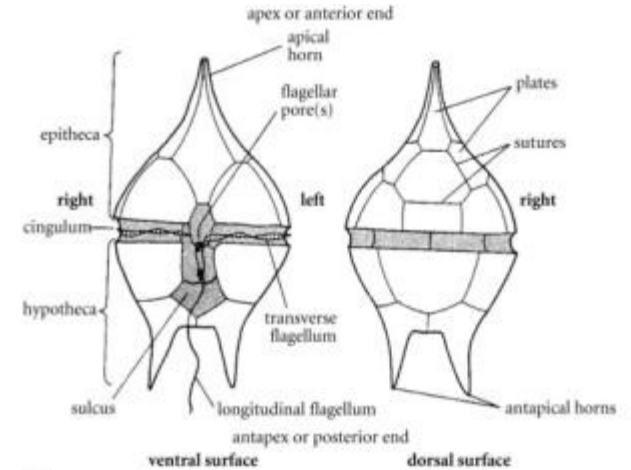
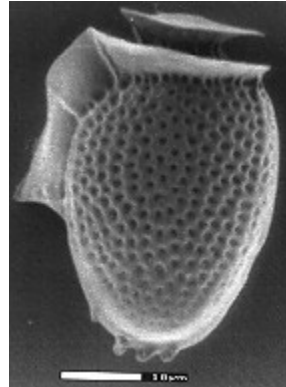
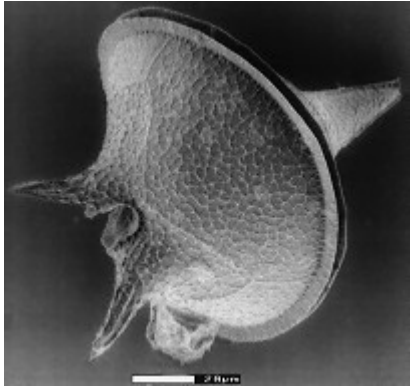
Alga

Ordoviciano -
Recente



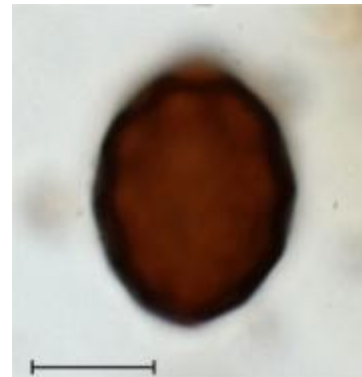
Dinoflagelad (Cambriano) Triássico – Recente

OS Protistas fotossintetizantes, geralmente classificados como algas



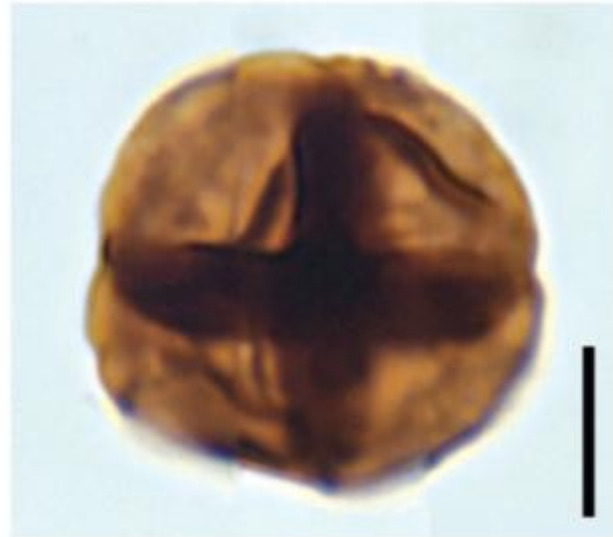
Esporos e outras partes de fungos

Jurássico - Recente

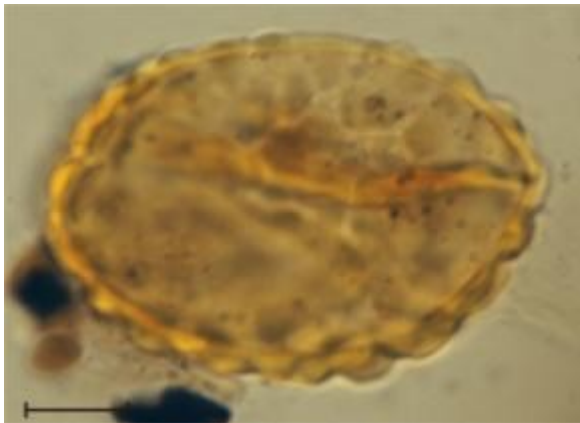
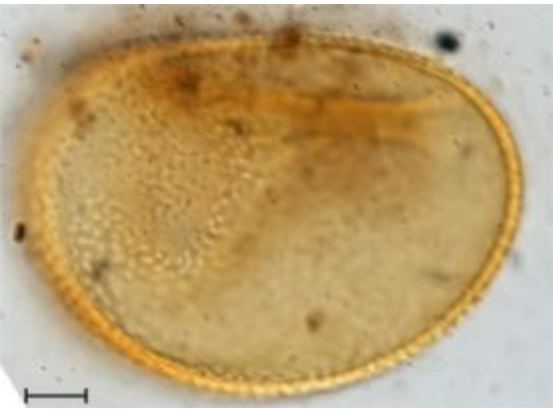


Criptoesporo

§ Cambriano - Siluriano

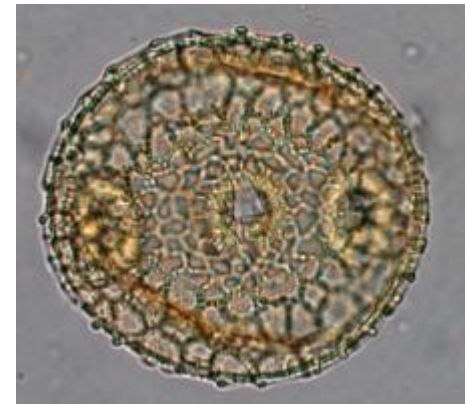
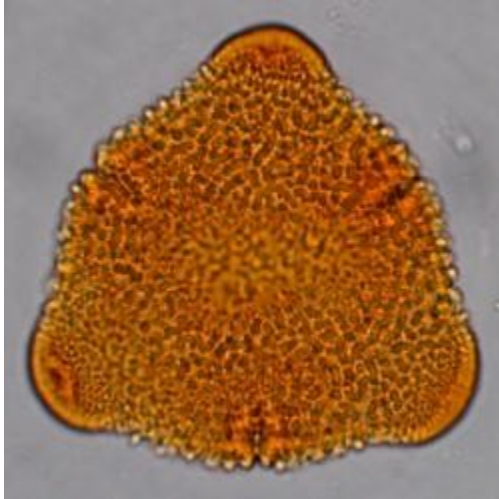


Esporos de embriófitas Ordoviciano Superior - Reciente



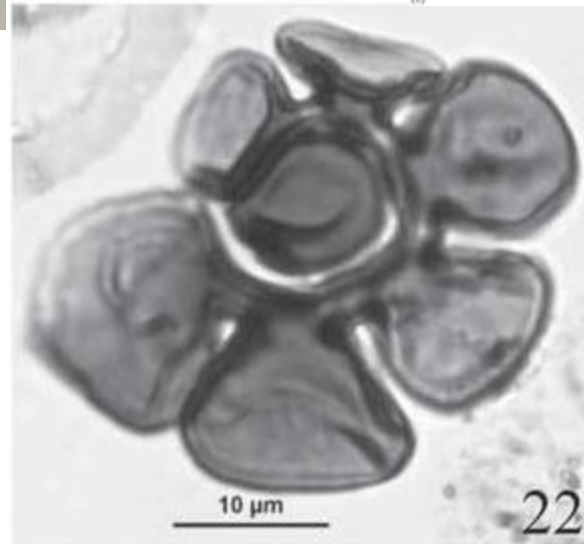
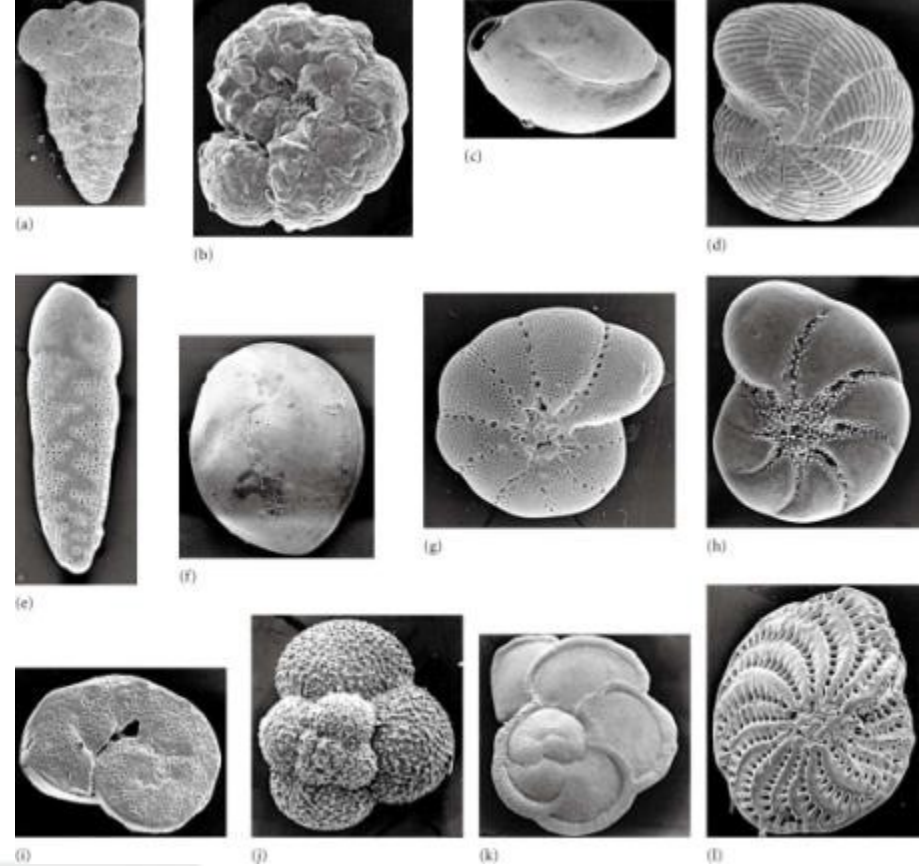
Grãos de pólen

Devoniano Superior - Recente



Foraminíferos

(Cambriano) Devoniano -
Recente

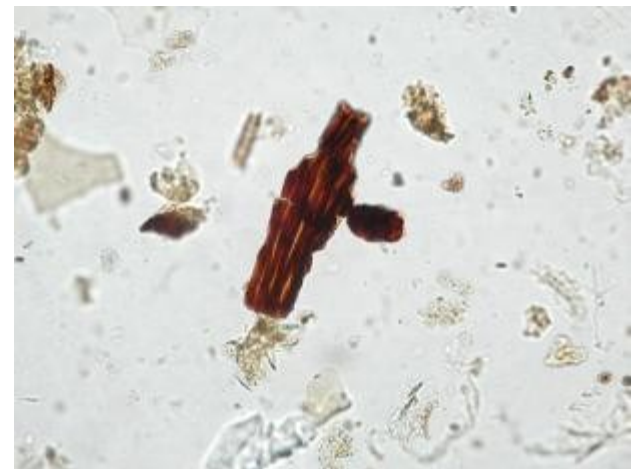
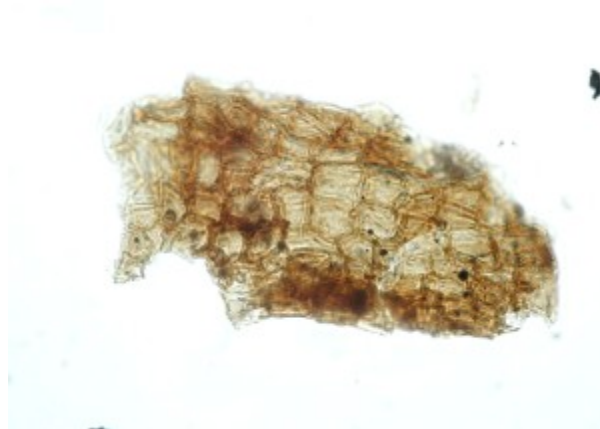
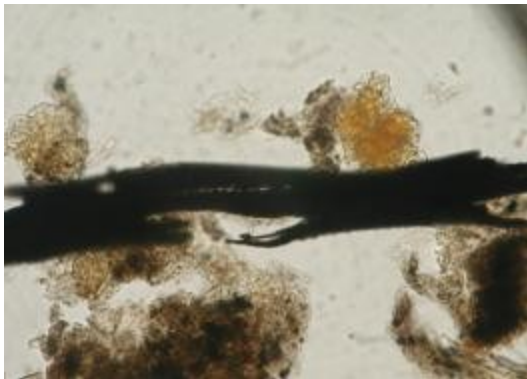
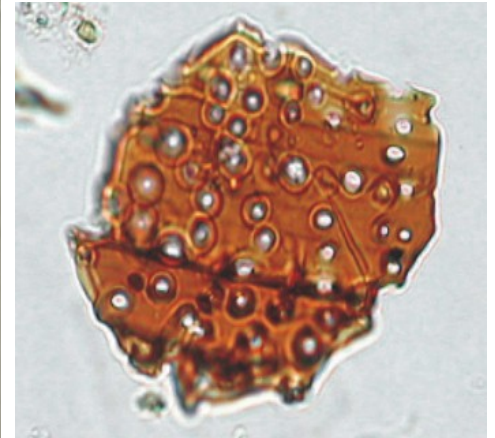
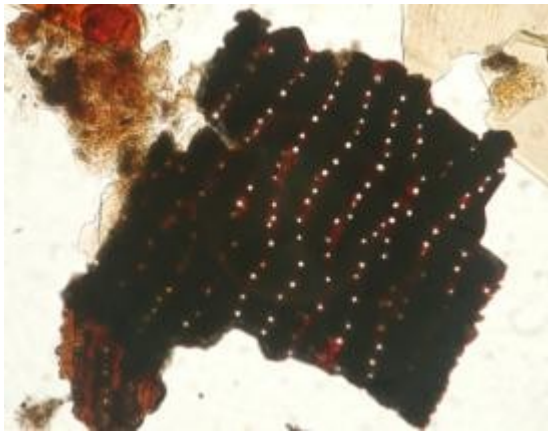


Outros

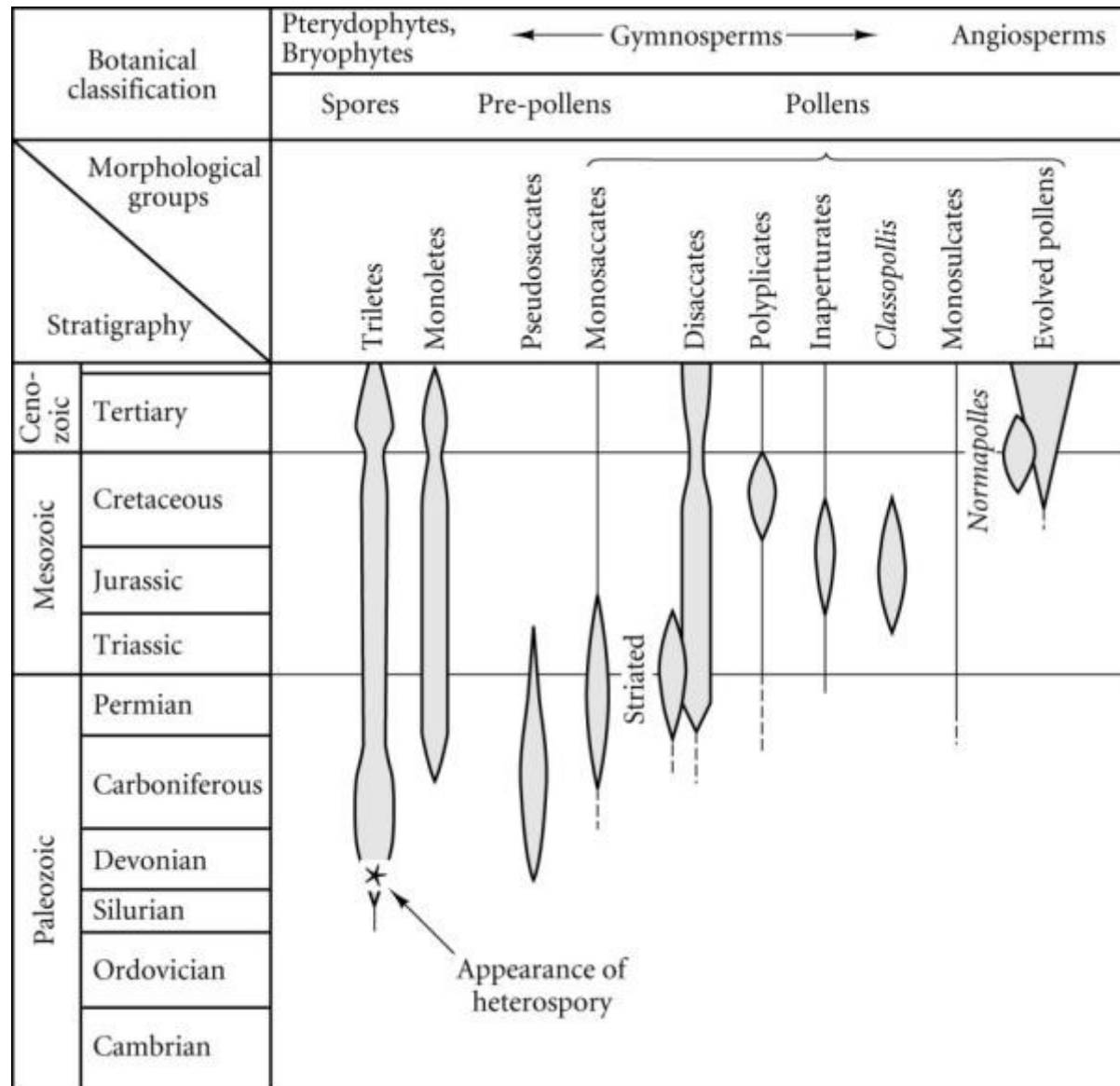
Carvão, fragmentos de cutículas, celulose, matéria orgânica amorfa

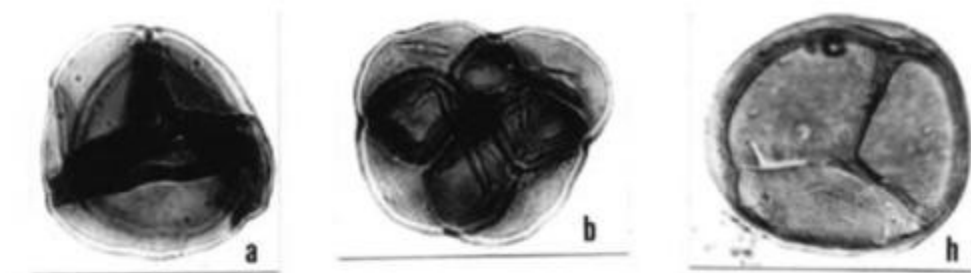
➤ Palinofácies

Proterozóico - Recente



BUIÇÃO ESTRATIGRÁFICA - ESPOROS E GRÃOS DE PÓLEN





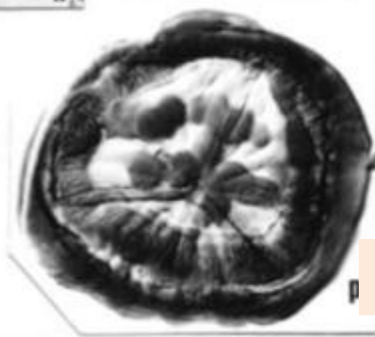
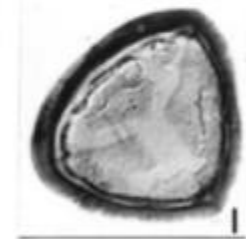
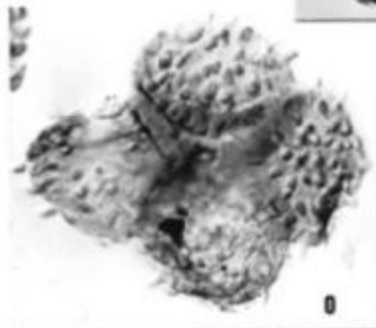
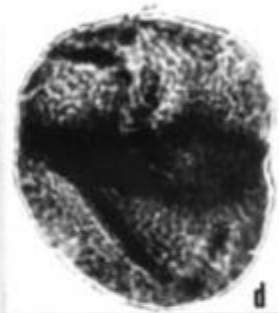
50 μ m



50 μ m



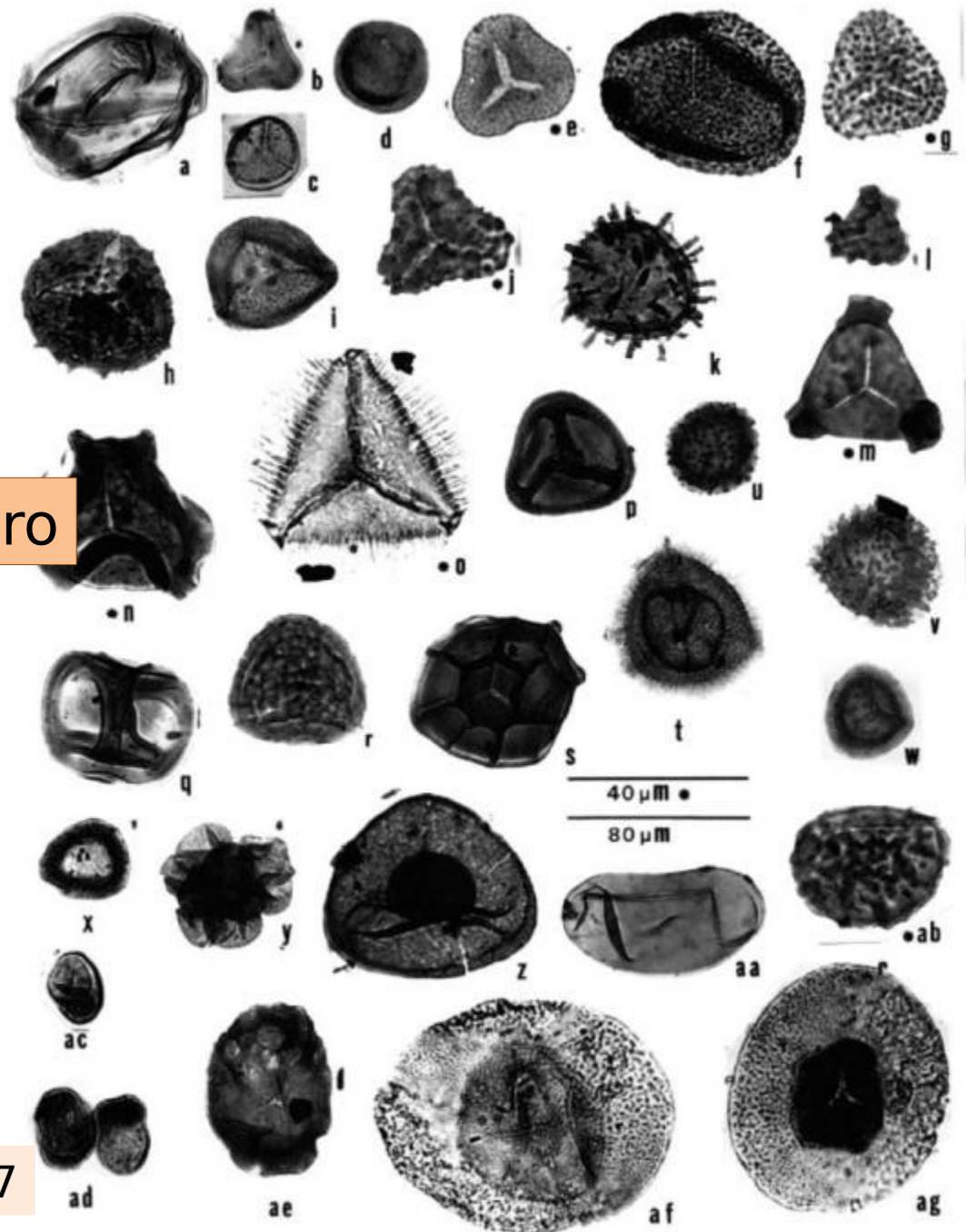
25 μ m



Palinomorfos do Siluriano

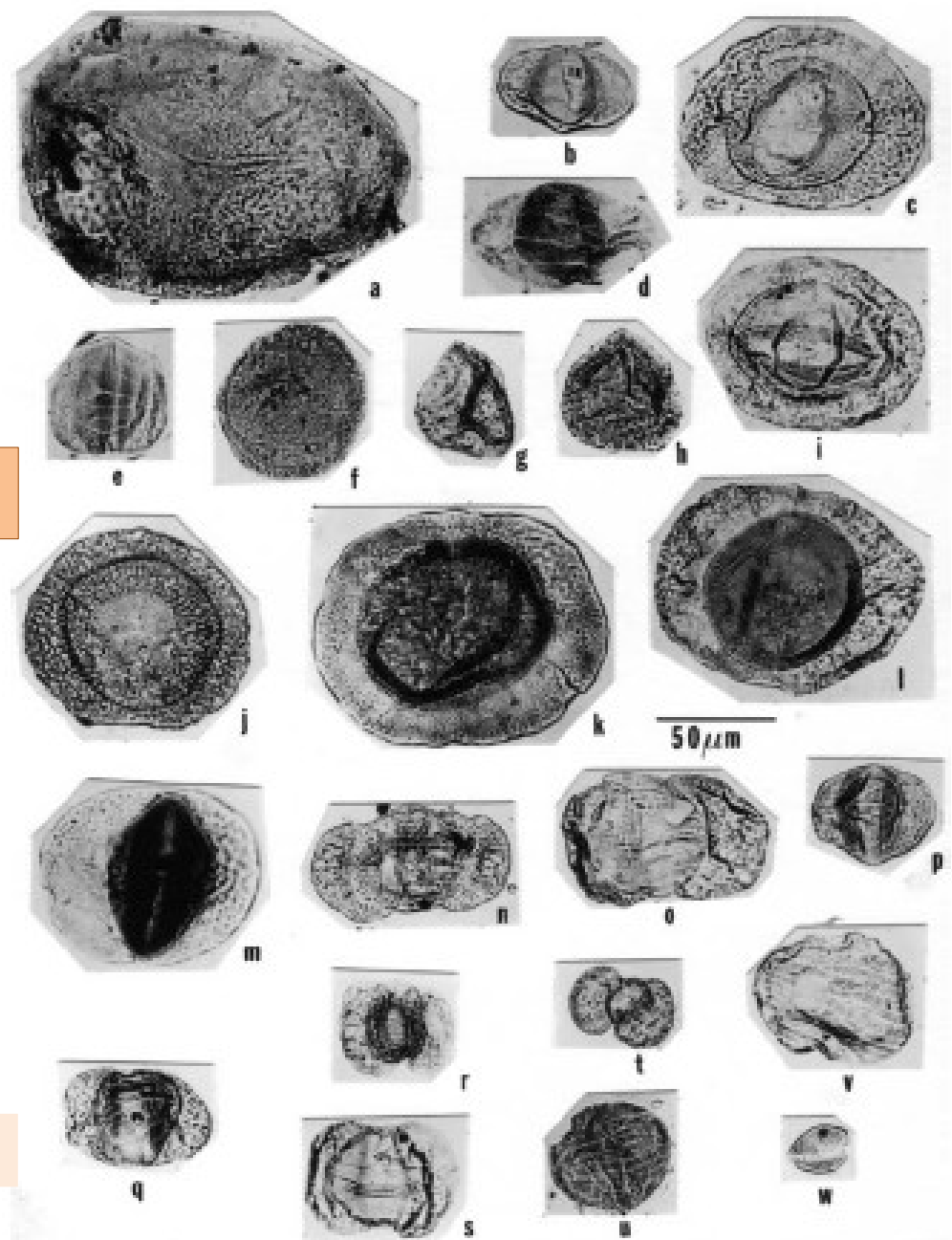
Traverse, 2007

Alinomorfos do Carbonífero



Traverse, 2007

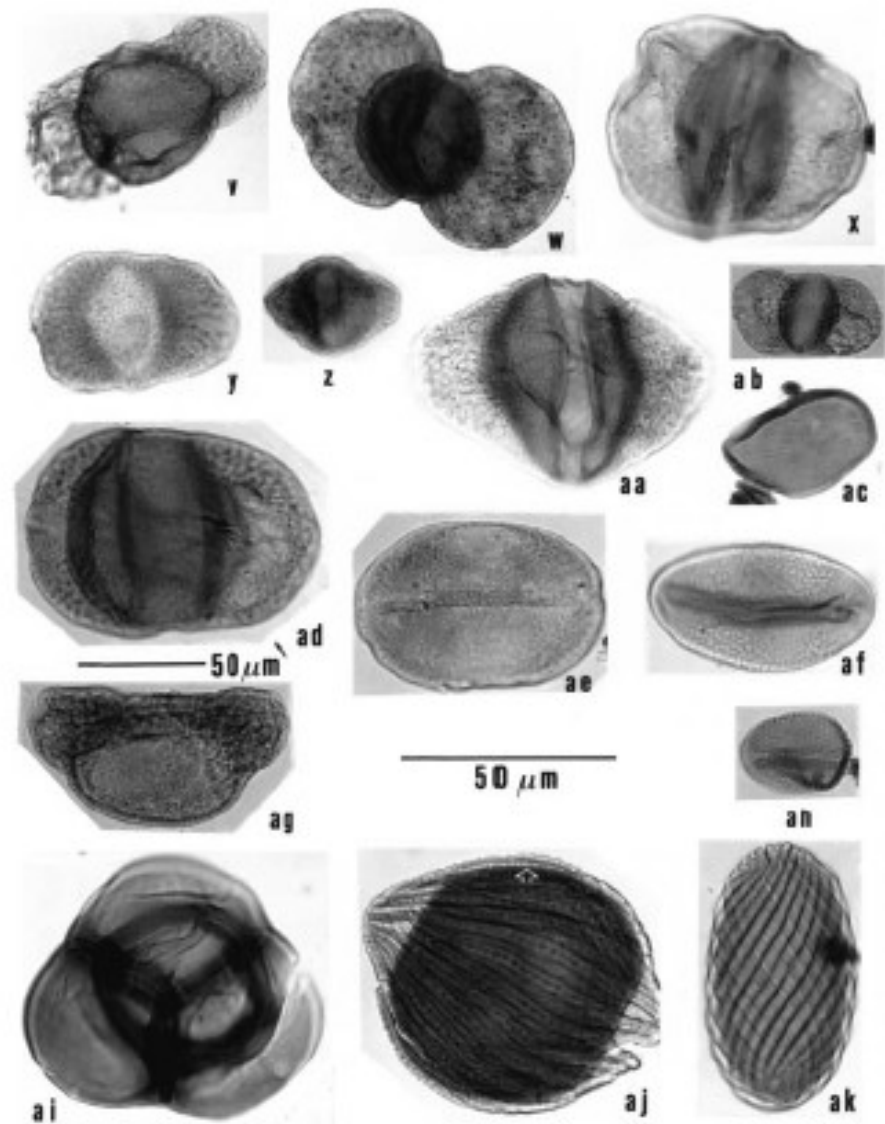
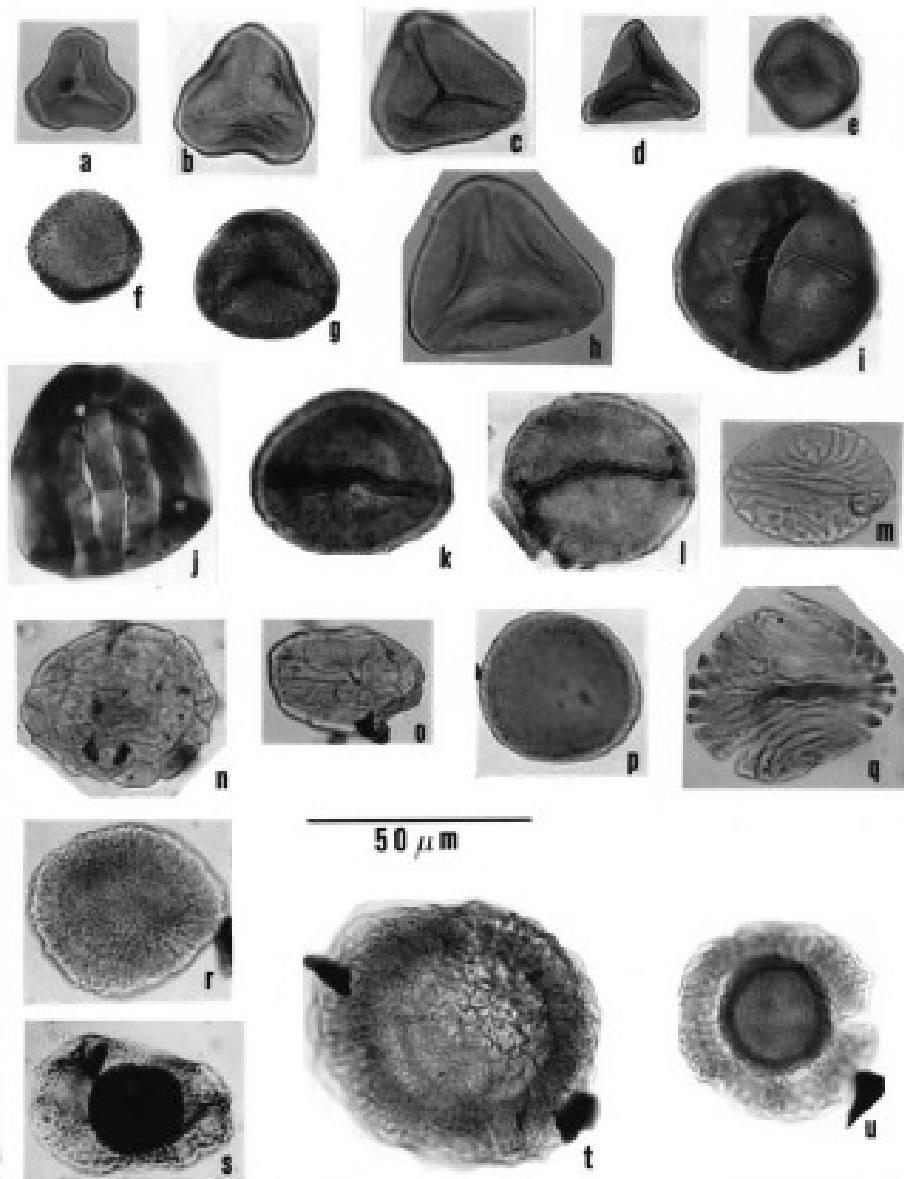
Palinomorfos do Carbonífero



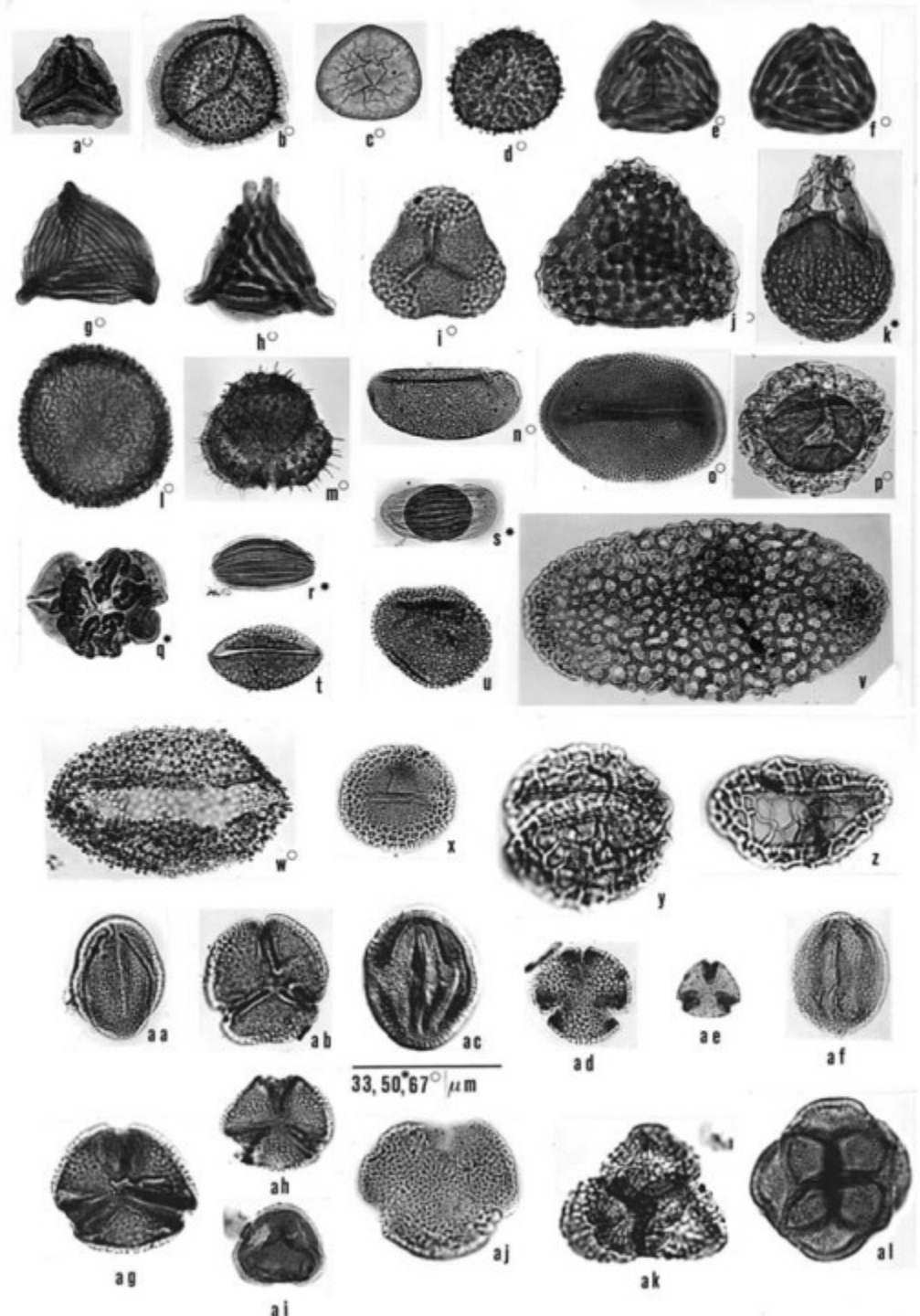
Traverse, 2007

Palinomorfos Triássico

Traverse, 2007

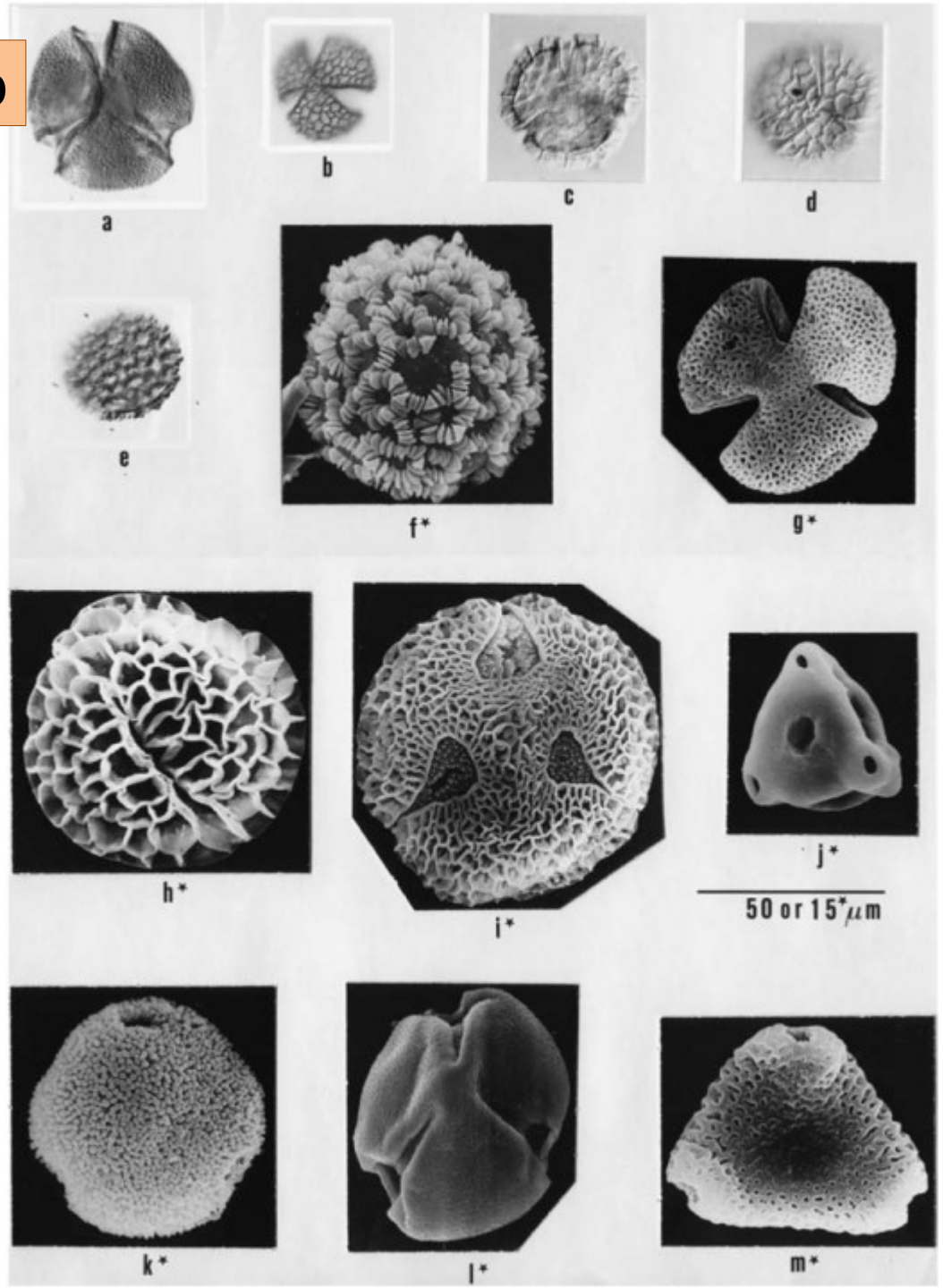


Palinomorfos do Cretáceo



Traverse, 2007

Palinomorfos do Cretáceo

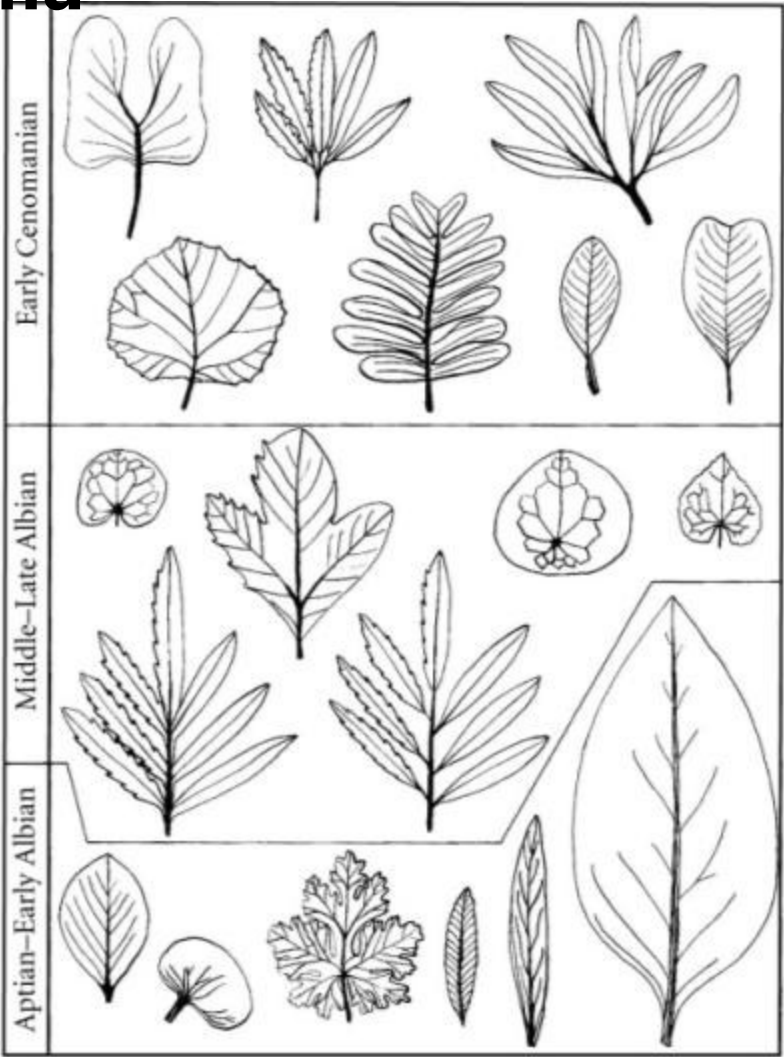


Traverse, 2007

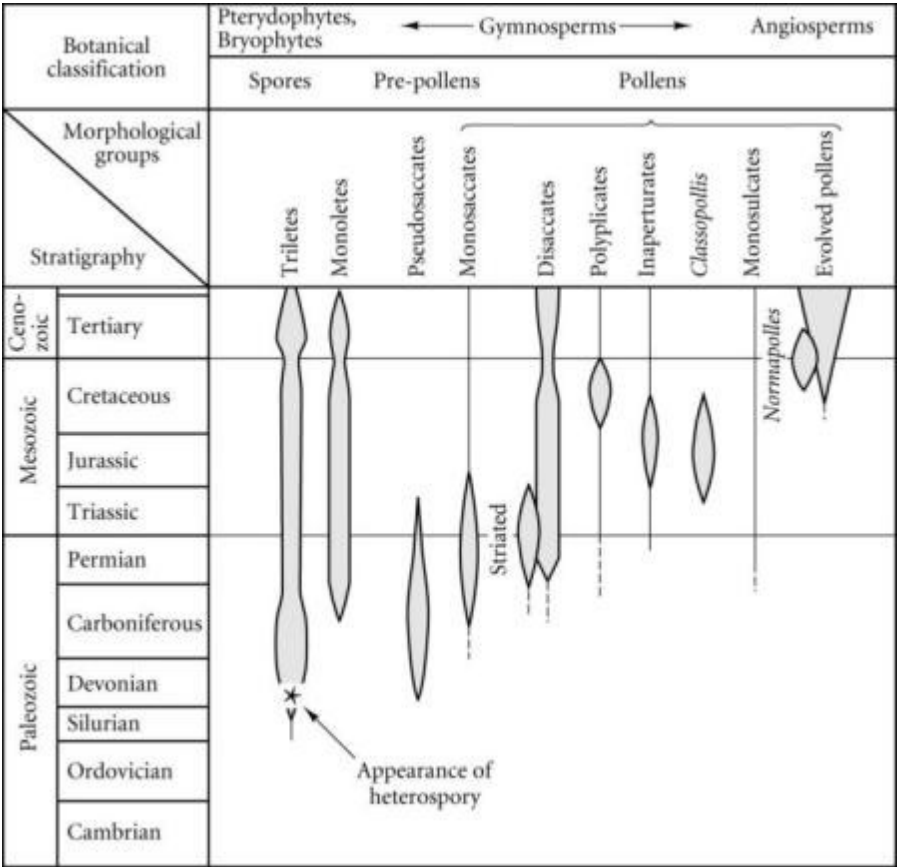
Paleobotânica - Aplicações

Paleobotânica e Palinologia:

Aplicações Bioestratigráficas



(a)



Macrofitofósseis

- Afinidade filogenética
- Características morfológicas associadas a adaptações a condições climáticas

Palinologia

- Quaternário - Reconstituição de comunidades vegetais

TABLE 1. Summary of the fossil wood taxa described from Cretaceous and Tertiary sediments of Antarctica. ¹From Mabberley (1997) and Heywood (1998)

Taxon	Affinity based on wood characters	Locality	Age	New record of family in the Antarctic flora	Modern distribution of closest modern taxa ¹ (NLR)
<i>Laurelites jamesrossi</i> Poole & Francis, 1999	Atherospermataceae: <i>Laureliopsis</i> Schodde	James Ross Island	Cretaceous	✓	temperate South America to Australasia and in valleys with subtropical aspects
<i>Atherospermoxylon</i> sp. (Poole & Gottwald, submitted)	Atherospermataceae: <i>Daphnandra</i> Benth., <i>Laurelia</i> Juss.	Seymour and Vega Islands	Cretaceous and Tertiary	(✓)	temperate South America to Australasia and in valleys with subtropical aspects
<i>Weinmannioxylon nordenskjöldii</i> Petriella (Poole <i>et al.</i> , 2000)	Cunoniaceae	James Ross and Livingston Islands	Cretaceous	×	warm temperate, some subtropical
<i>Illicioxylon</i> species (Poole, Gottwald & Francis, 2000)	Illiciaceae: <i>Illicium</i>	James Ross, Vega and Seymour Islands	Cretaceous and Tertiary	✓	subtropical and warm temperate
<i>Sassafrasoxylon gottwaldii</i> Poole, Richter & Francis, (2000)	Lauraceae: <i>Sassafras</i>	James Ross and Seymour Islands	Cretaceous	×	subtropical and temperate

Macrofitófósseis

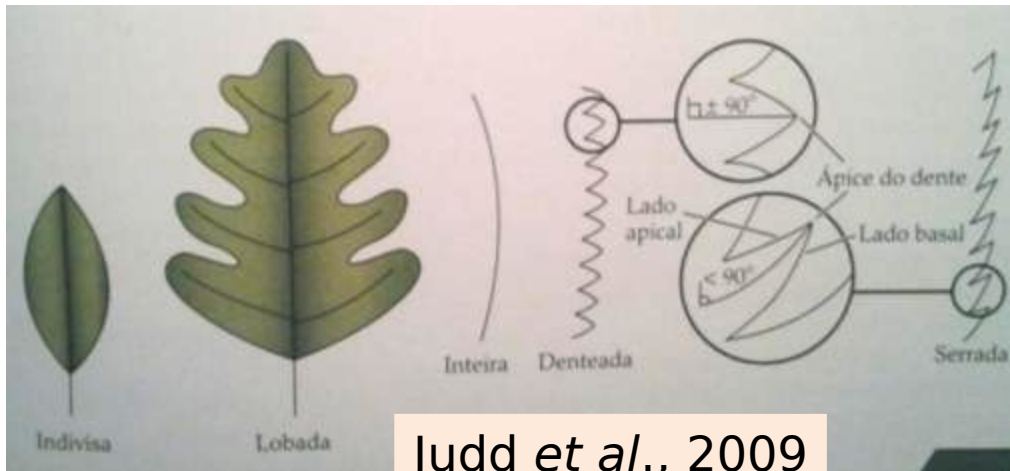
➤ Características morfológicas associadas a adaptações a condições climáticas e a forma das folhas apresentam uma forte correlação com a temperatura e a umidade.

A relação entre “morfologia foliar - clima” pode ser usada como um *proxy* paleoclimático.

Margem foliar denteada



Correlação negativa com a temperatura média anual



Judd *et al.*, 2009

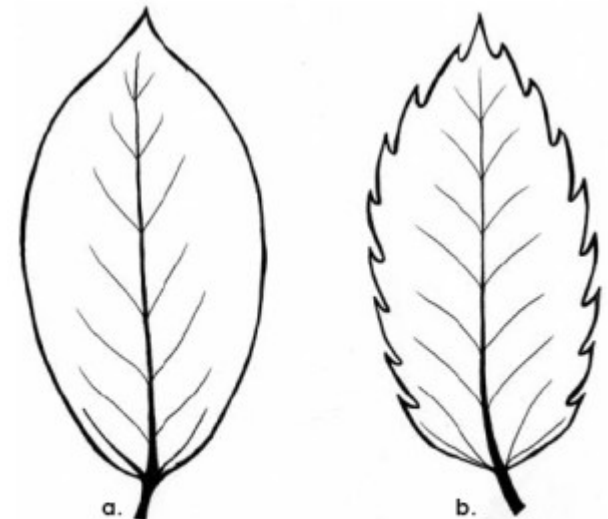
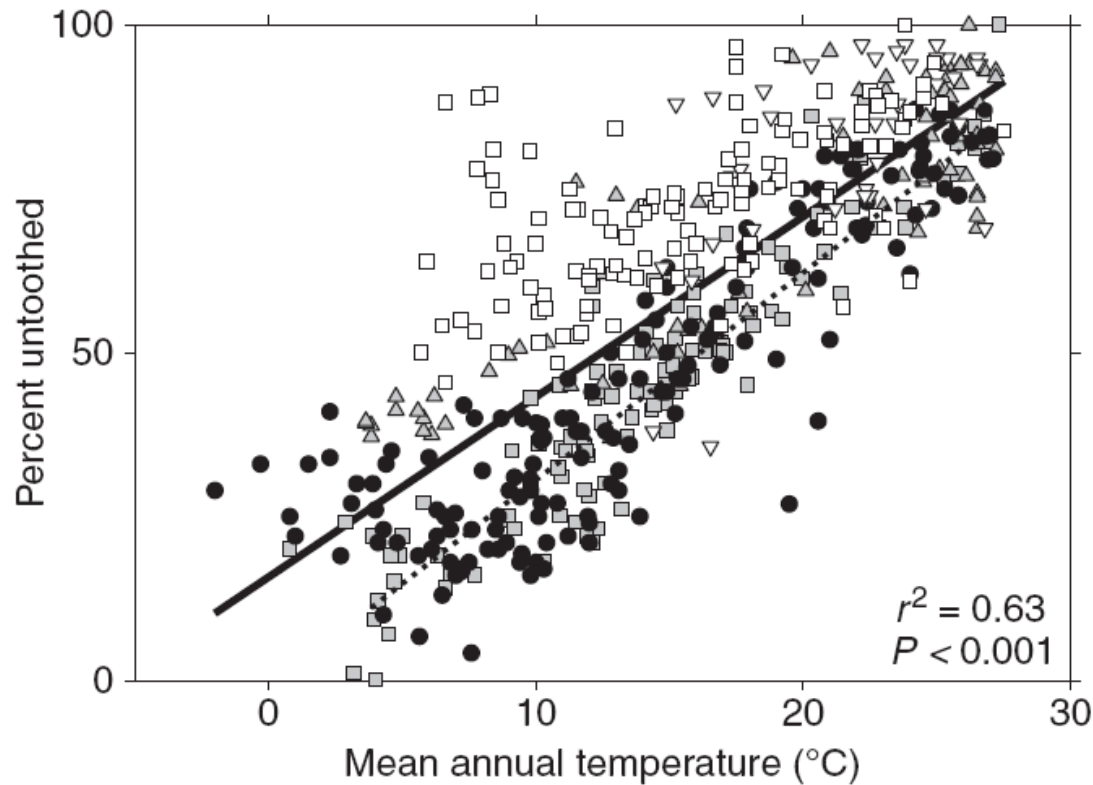


Figure 2. Leaf Margin Type. Proportion of (a) entire (smooth) margined leaves to (b) toothed margined leaves used to determine MAT.

Margem foliar
denteada



Correlação negativa
com a temperatura
média anual



- North America, Central America, Europe
- Asia
- ▲ South America
- ▼ Africa
- Oceania (Australia, NZ, Fiji, New Caledonia)

Peppe *et al.*, 2011

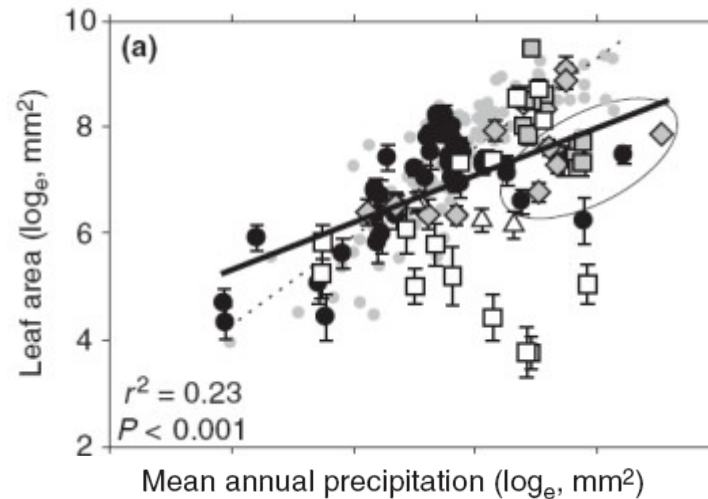
Macrofitófósseis

➤ Características morfológicas associadas a adaptações a condições climáticas

Tamanho das
folhas



Disponibilidade de
água



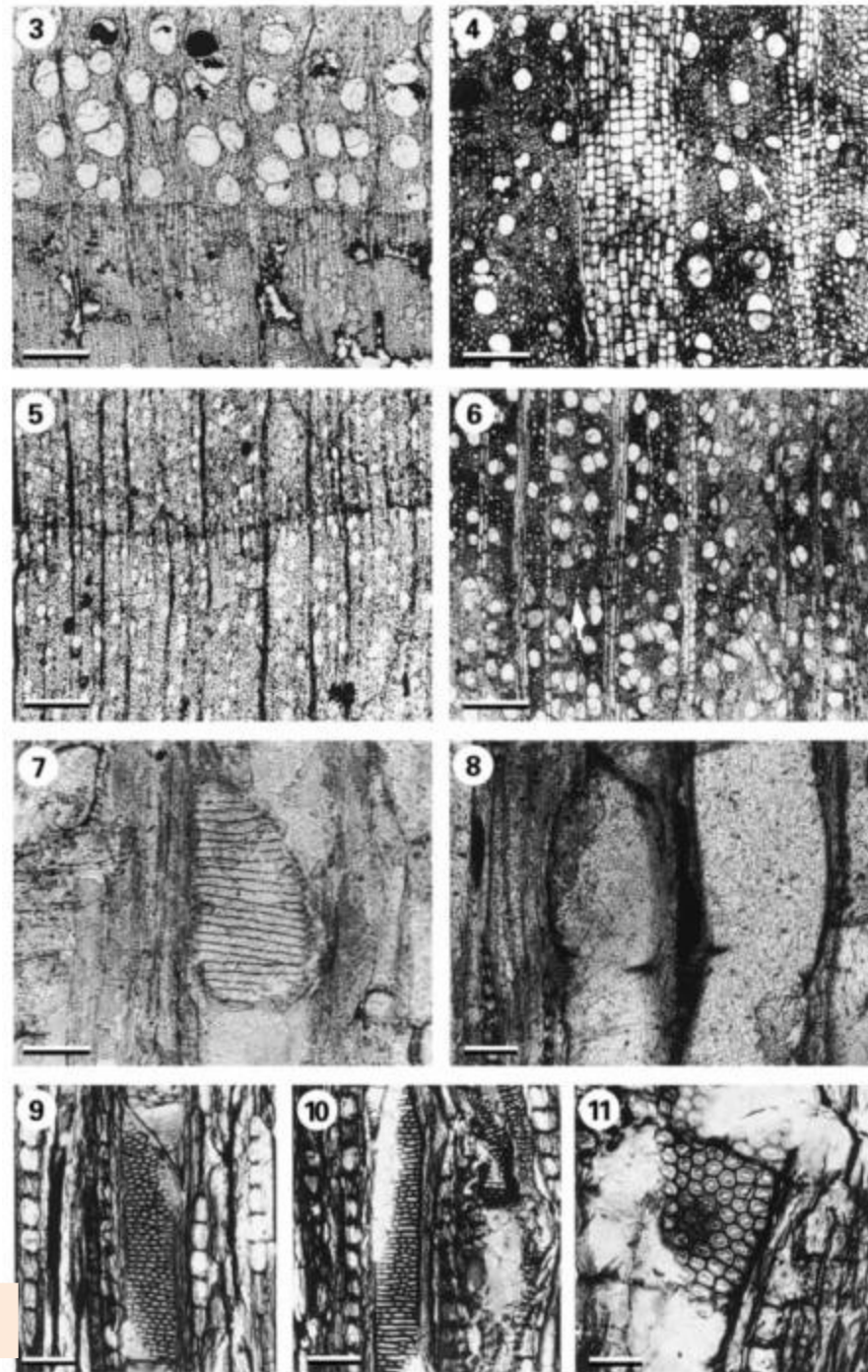
- North America and Europe
- Asia
- ◇ Central and N. South America and Caribbean islands
- △ S. South America
- Oceania (Australia, NZ, Fiji)



Macrofitofósseis

➤ Características morfológicas associadas a adaptações a condições climáticas

Características morfológicas de caules permineralizados



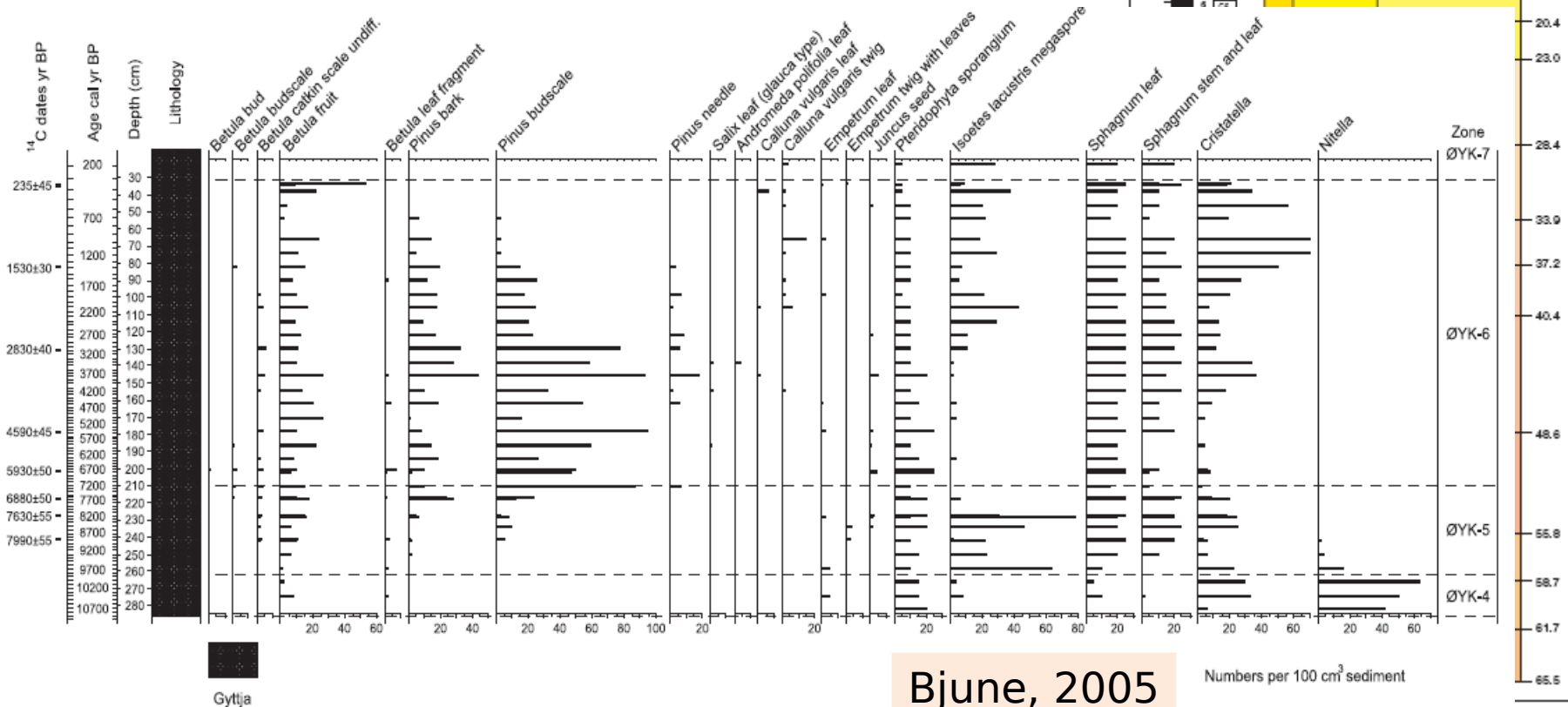
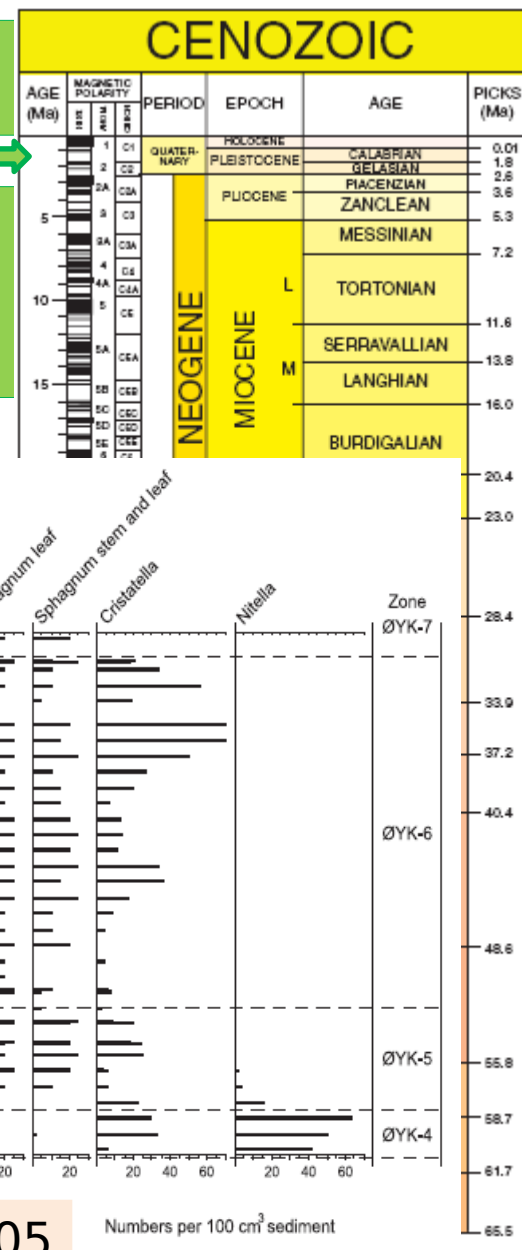
Poole, 2000

Aplicações

➤ Quaternário

Macrofósseis e Palinomorfos

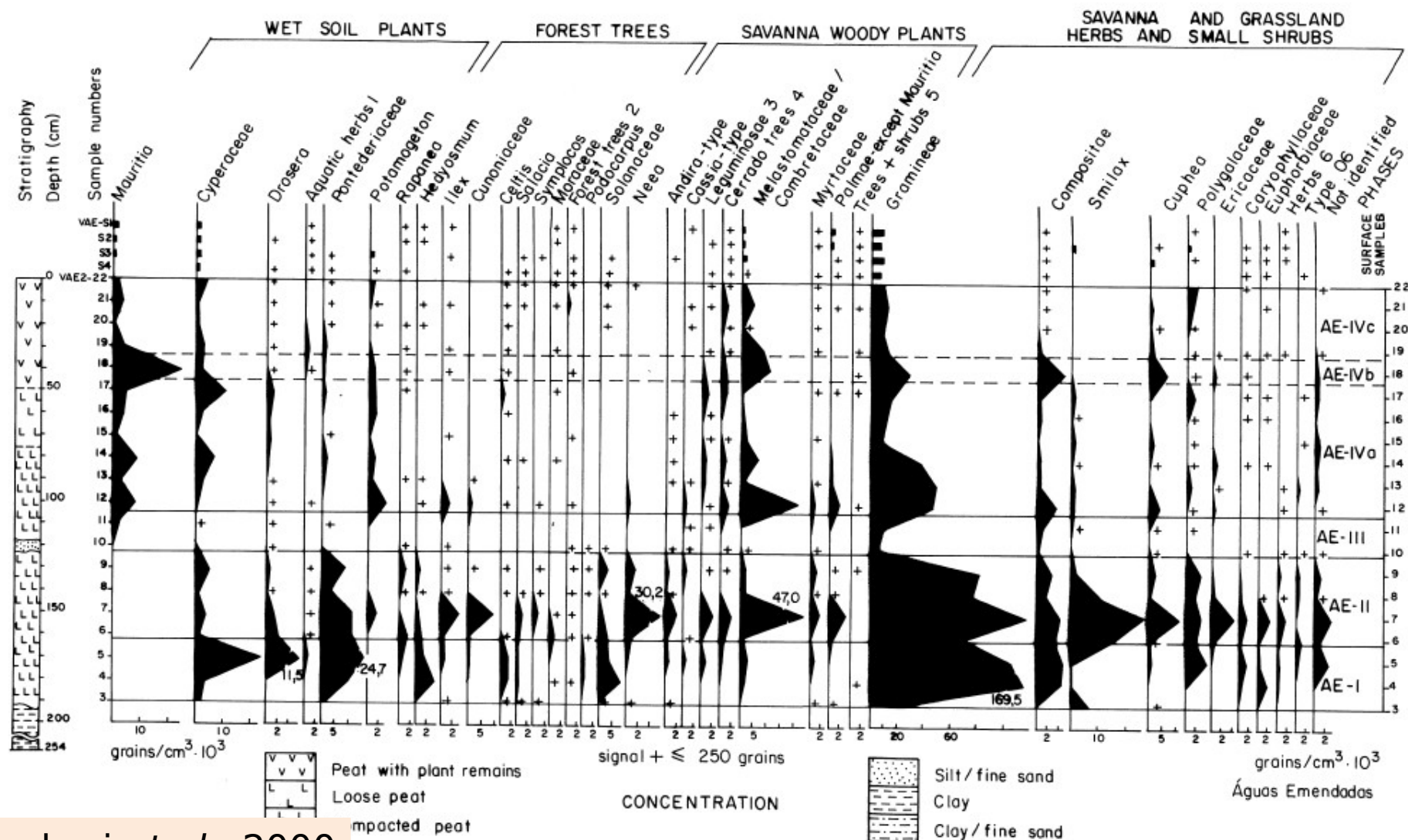
➤ Reconstituição de comunidades vegetais





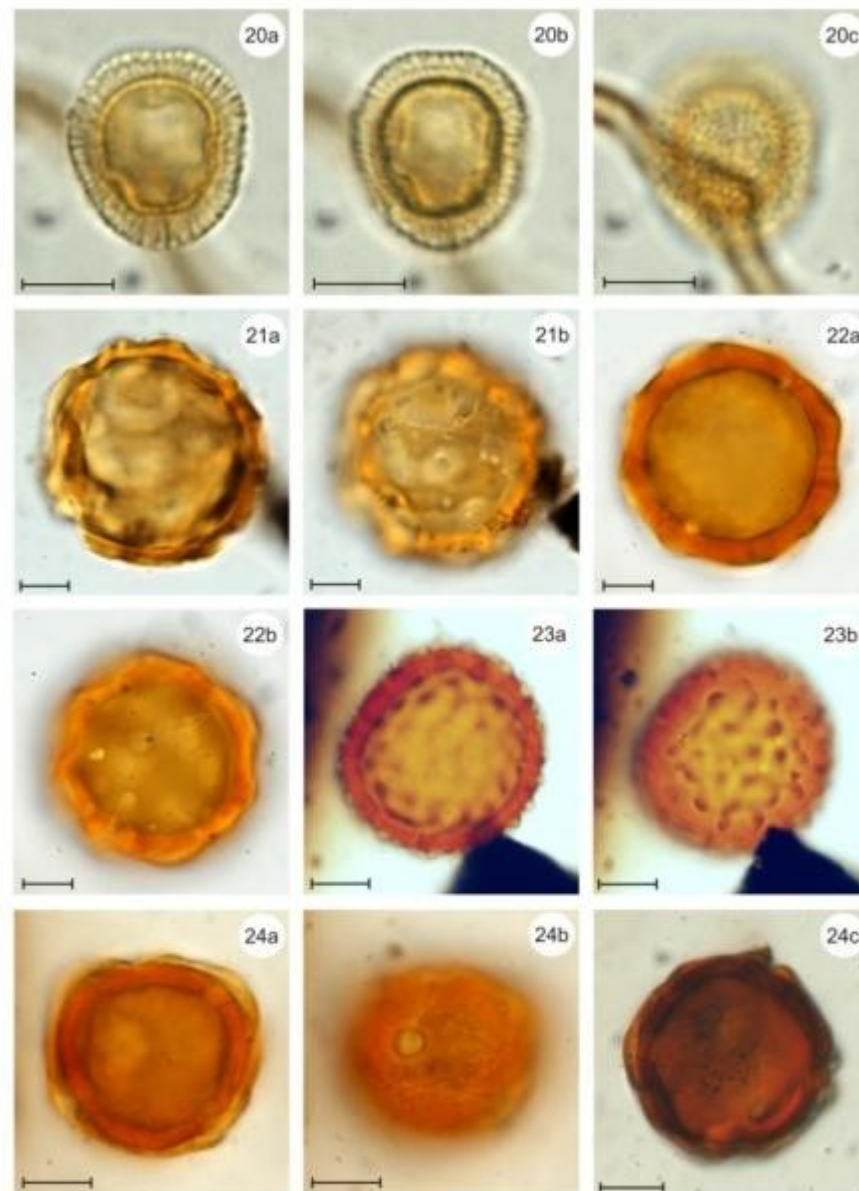
Kienast *et al.*, 2011

➤ Grãos de Pólen - Quaternário





Legenda: 29 a 31- Euphorbiaceae (continuação): 29a-c: Tipo *Tragia lagoensis* (29a: VE, exina; 29b: VE, aberturas; 29c: ornamentação). 30a-d: Tipo *Maprounea brasiliensis* (30a: VE, corte ótico; 30b: aberturas; 30c: detalhe da ornamentação; 30d: VE, exina e aberturas). 31a-b: Tipo *Alchornea* (31a: VP; 31b: VP, abertura com opérculo). **32- Caryocaraceae**: 32a-d: *Caryocar brasiliense* (32a e 32b: VE, saliências polares e orais; 32c e 32d: VE, abertura e ornamentação). Escala= 10µm. (VP= Vista Polar, VE= Vista Equatorial).



Legenda: 20- Celastraceae: 20a-c *Plenckia populnea* (20a: VE, corte ótico; 20b: aberturas; 20c: ornamentação). **21 a 24- Malpighiaceae**: 21a-b: Tipo *Heteropterys* (21a: corte ótico; 21b: aberturas); 22a-b Tipo *Camarea* (22a: corte ótico; 22b: aberturas). 23a-b: Tipo *Mascagnia* (23a: corte ótico; 23b: ornamentação). 24a-d: Tipo *Peixotoa* (24a e 24c: corte ótico; 24b: aberturas). Escala= 10µm. (VE= Vista Equatorial).

AULA PRÁTICA

1. IDENTIFIQUE CADA TÁXON REPRESENTADO, ANALISE A SUA DISTRIBUIÇÃO ESTRATIGRÁFICA E O SEU AMBIENTE DE VIDA.

2. DEFINA A IDADE E O AMBIENTE DE CADA CONJUNTO DE FÓSSEIS.