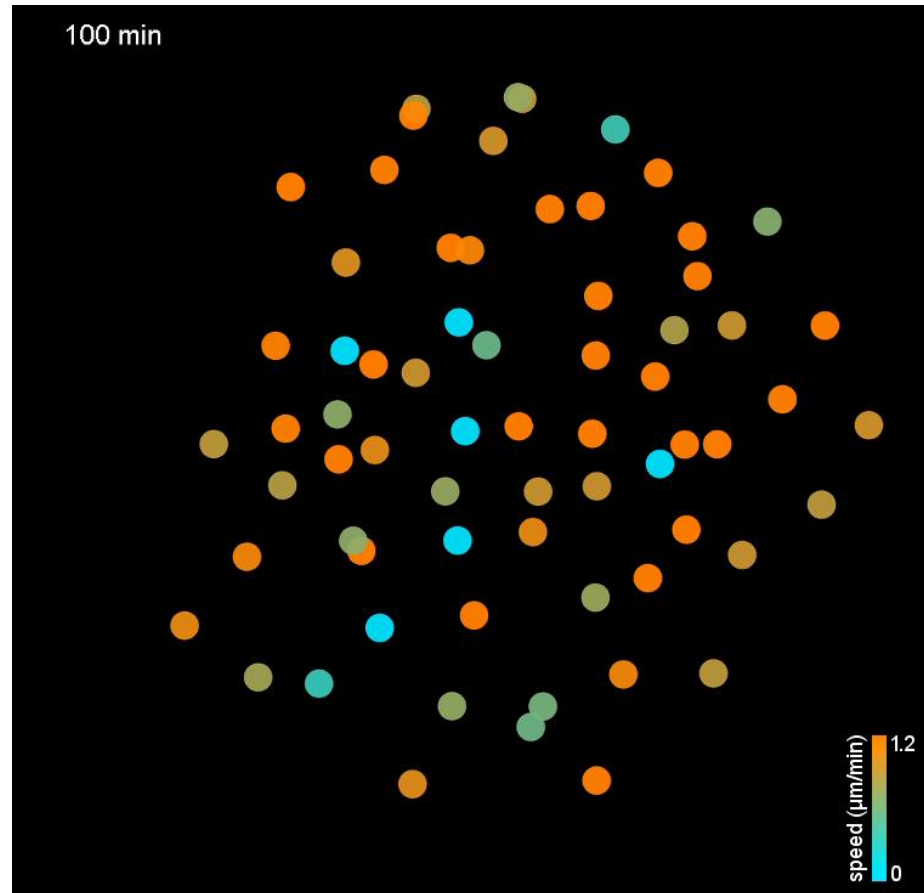


Etapas iniciales del desarrollo en metazoarios



Gonzalo Aparicio
gaparicio@fcien.edu.uy

Etapas iniciales del desarrollo en animales

Clivaje (o segmentación)

Blástula

Gastrulación

Embrión trilaminar:

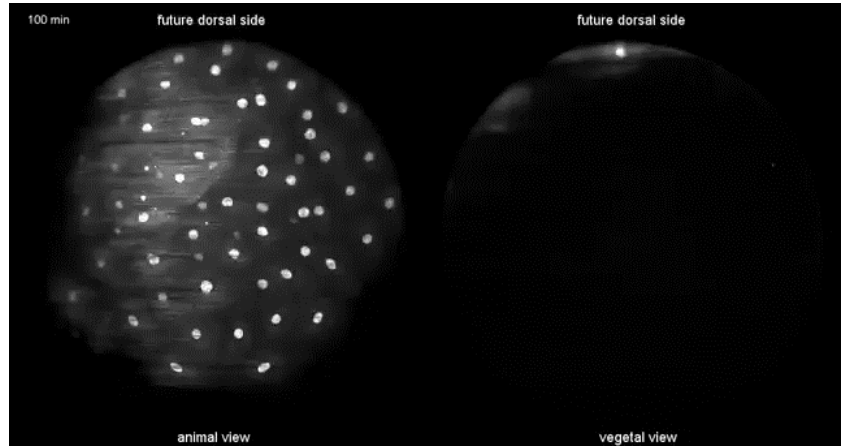
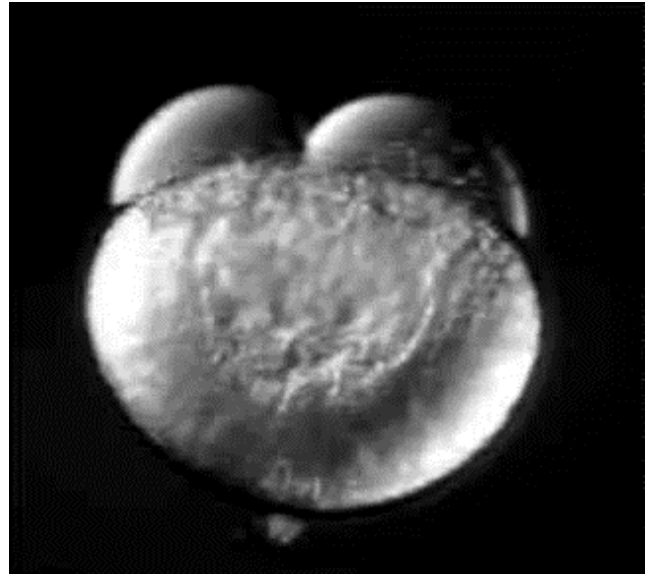
Endodermo

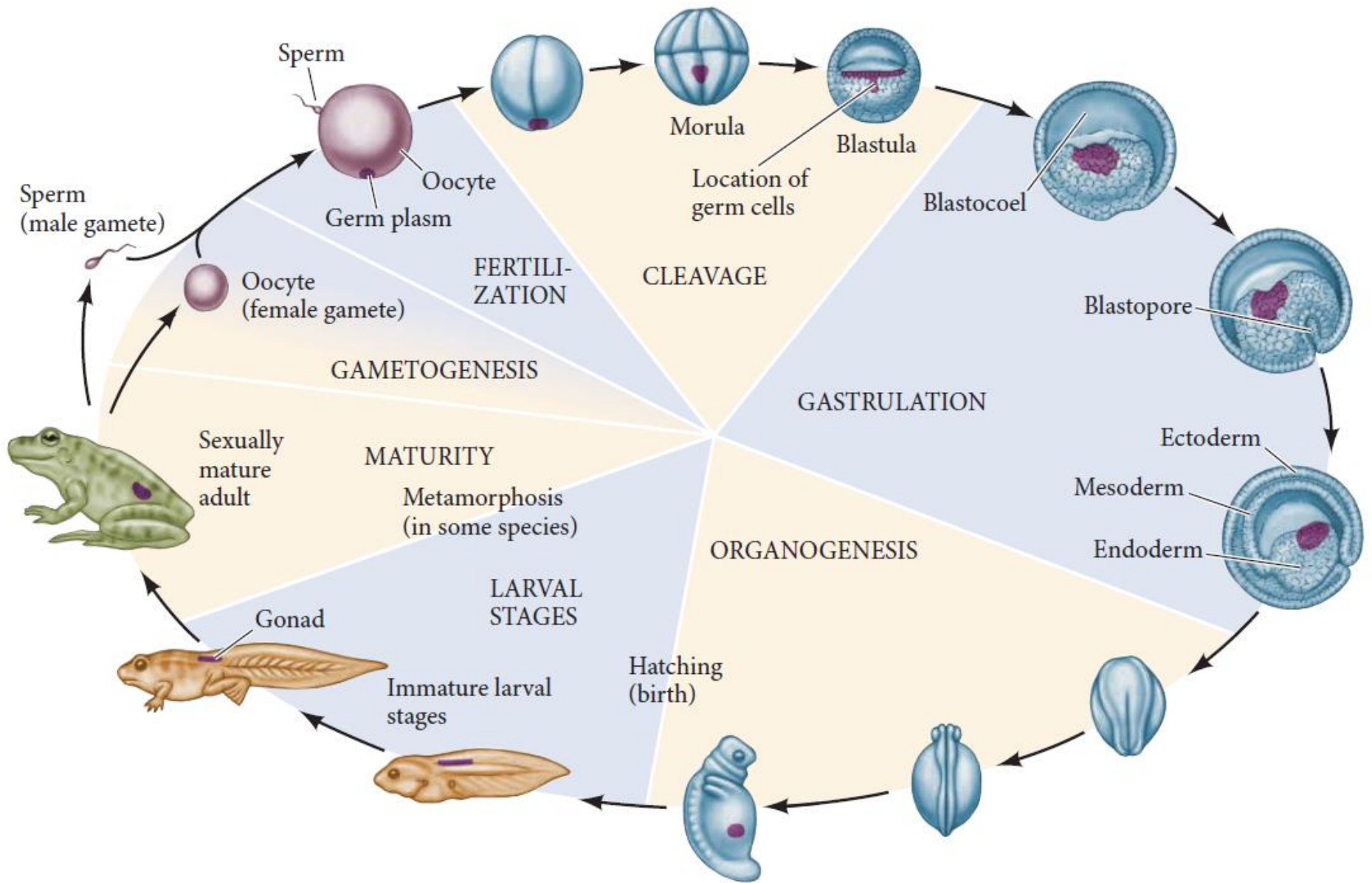
Mesodermo

Ectodermo

Neurulación

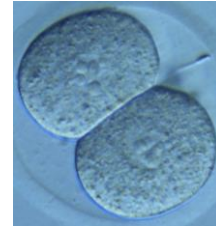
Sistema nervioso





Blast...

Blastómera



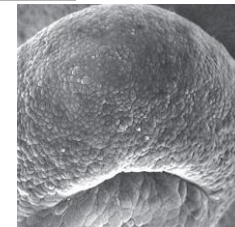
Blastocele



Blástula/Blastocista



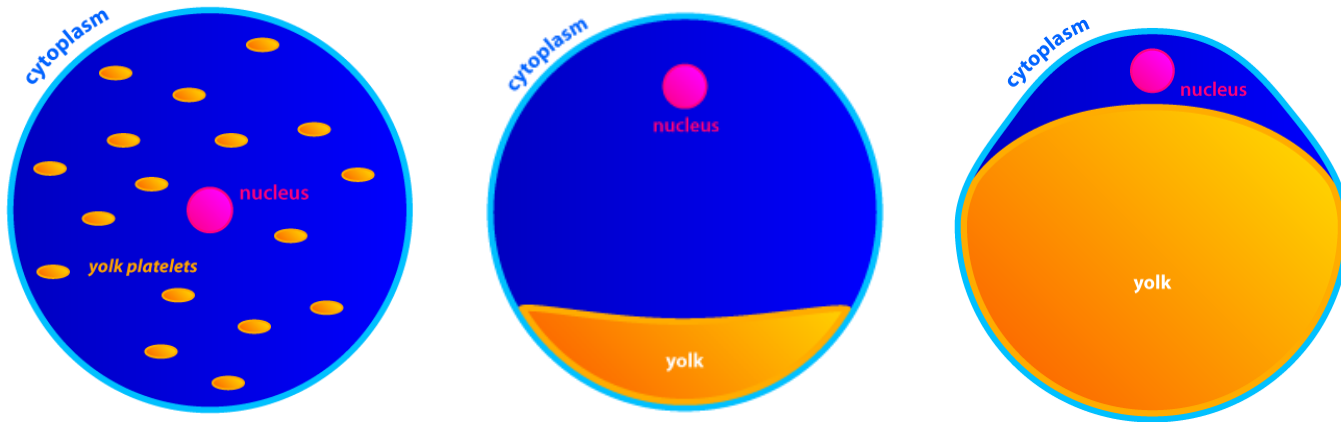
Blastoporo



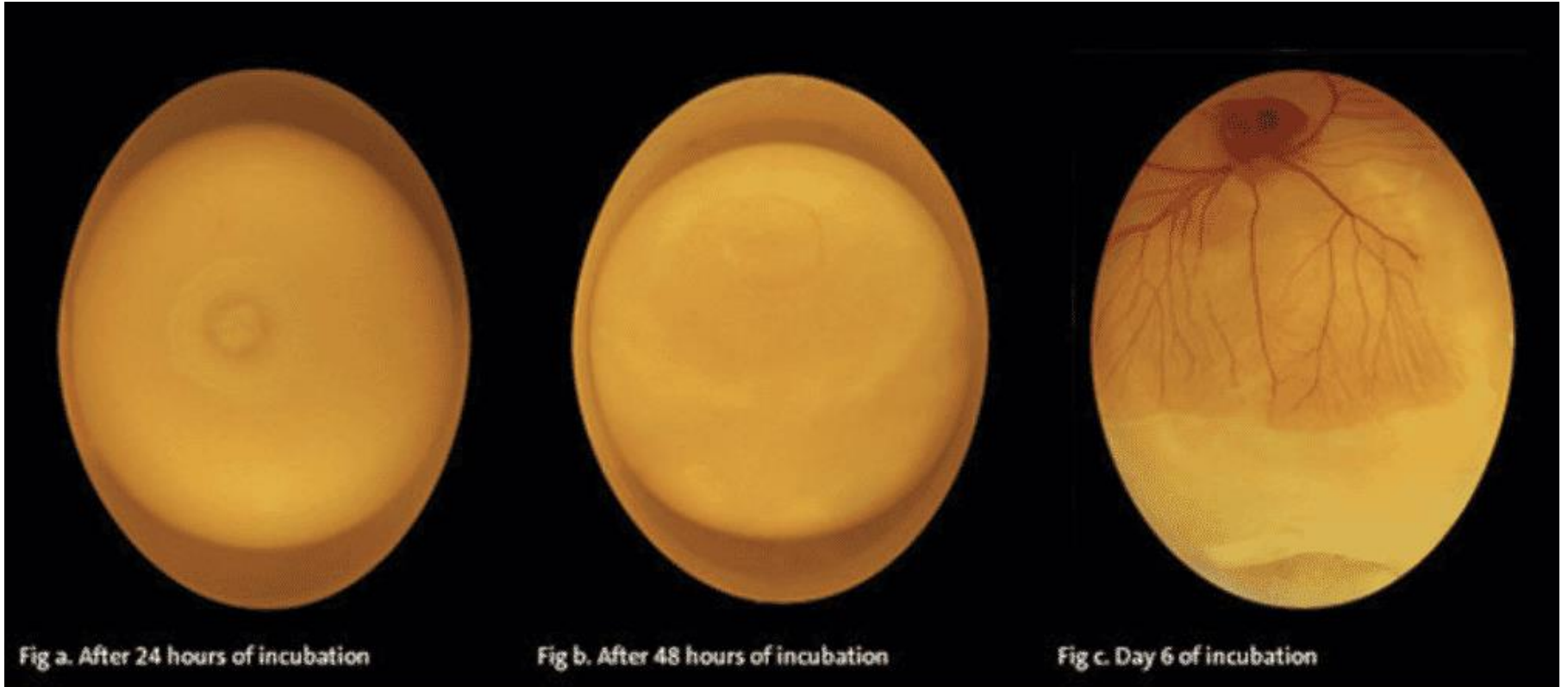
Clivaje

Serie de divisiones celulares iniciales que experimenta el embrión

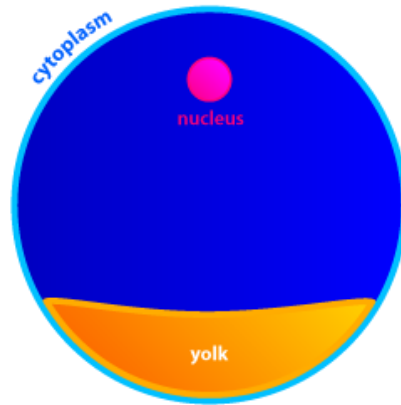
Orientación y velocidad de segmentación
condicionada por el contenido de **vitelo**



Vitelo



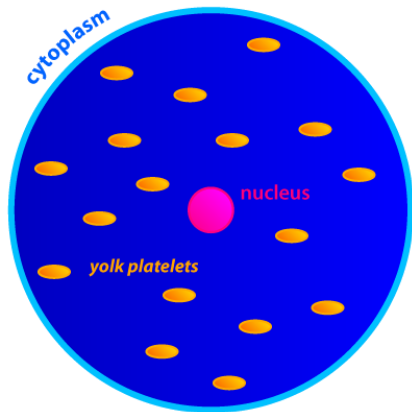
Polo Animal



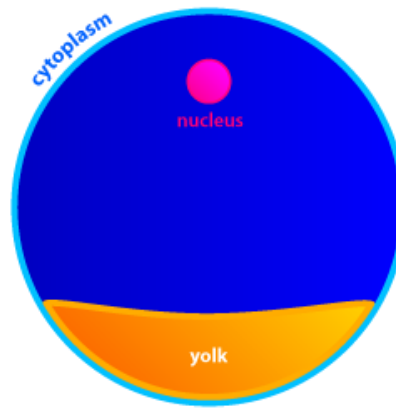
Polo vegetal



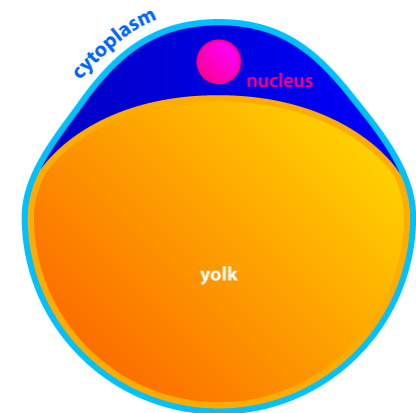
Cantidad de vitelo



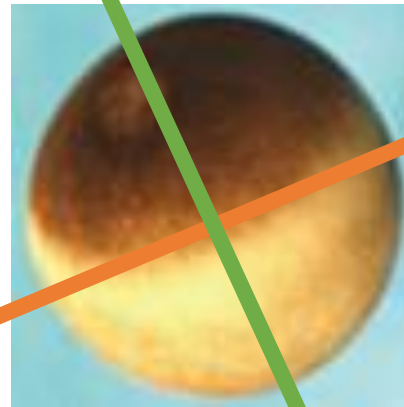
Isolecito
(cantidad vitelo escasa,
distribuido
homogéneamente)



Mesolecito
(cantidad de vitelo moderada,
distribuido
hacia la región vegetal)

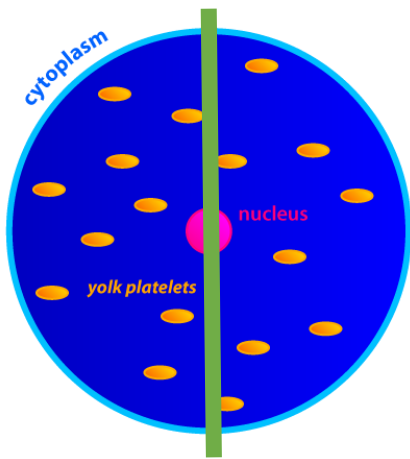


Telolecito
(gran cantidad de vitelo,
distribuido
en casi toda la célula)

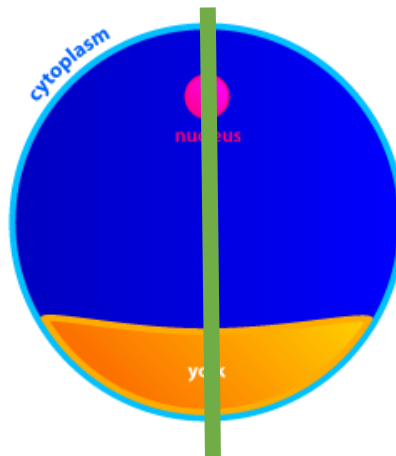


**Plano de división
ecuatorial**

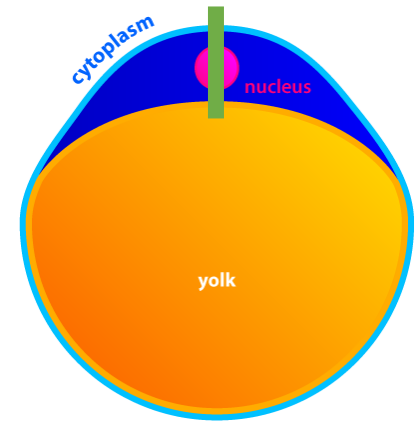
**Plano de división
meridional**



**Segmentación
Holoblástica
(completa)**



**Segmentación
Holoblástica
(completa)**



**Segmentación
Meroblástica
(parcial)**

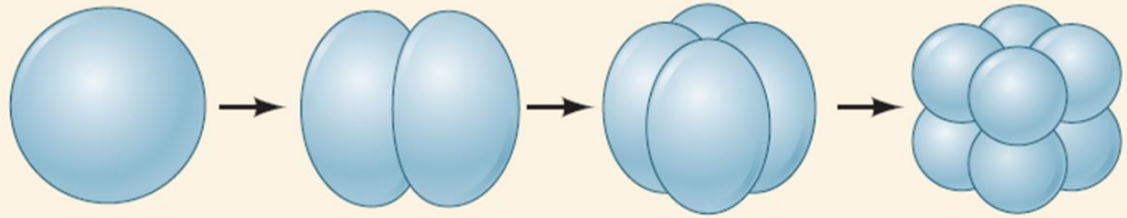
Clivaje en embriones con poco vitelo

I. HOLOBLASTIC (COMPLETE) CLEAVAGE

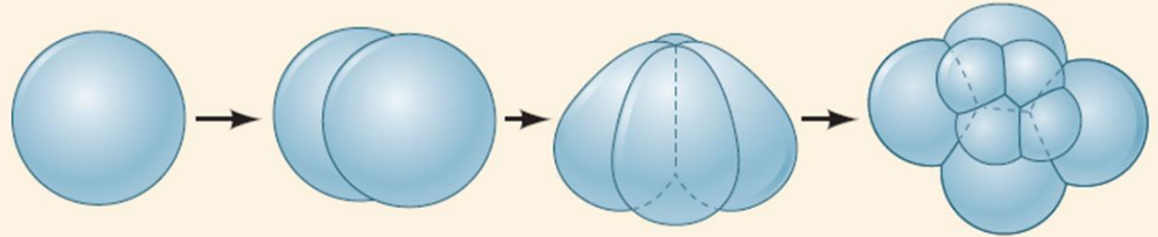
A. Isolecithal

(Sparse, evenly distributed yolk)

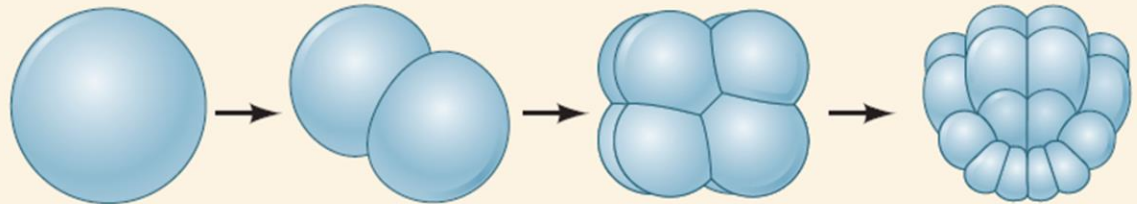
1. Radial cleavage
Echinoderms, amphioxus



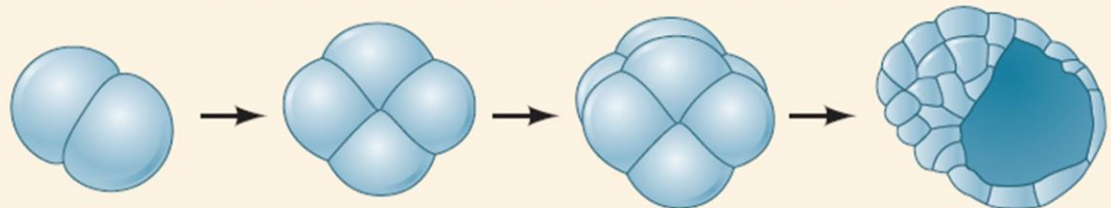
2. Spiral cleavage
Annelids, molluscs,
flatworms



3. Bilateral cleavage
Tunicates



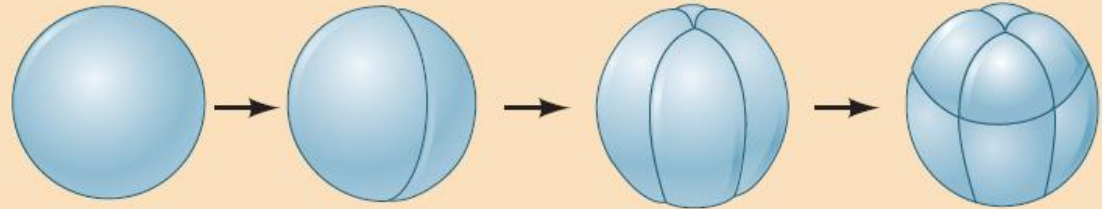
4. Rotational cleavage
Mammals, nematodes



Clivaje en embriones con mucho vitelo

B. Mesolecithal (Moderate vegetal yolk disposition)

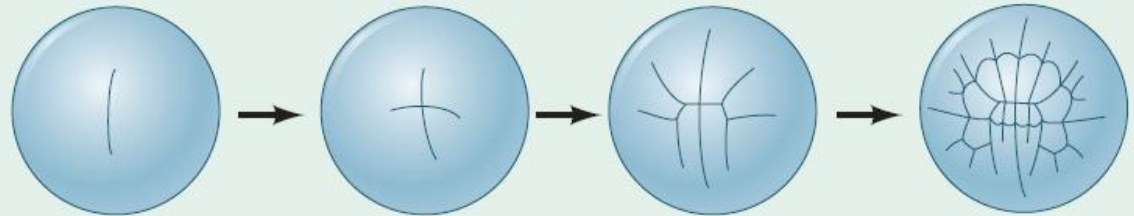
Displaced radial cleavage
Amphibians



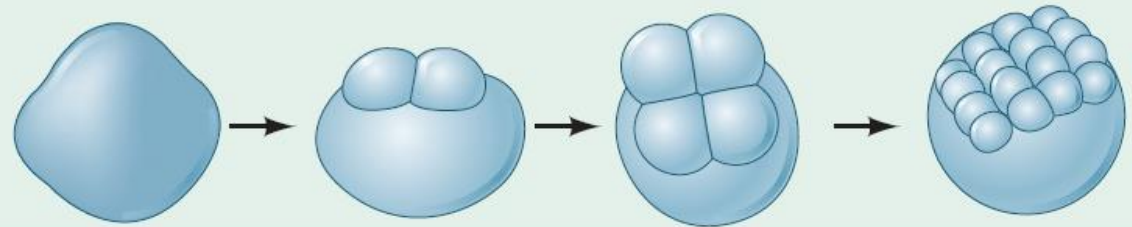
II. MEROBLASTIC (INCOMPLETE) CLEAVAGE

A. Telolecithal (Dense yolk throughout most of cell)

1. Bilateral cleavage
Cephalopod molluscs

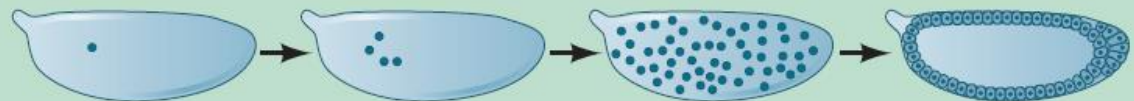


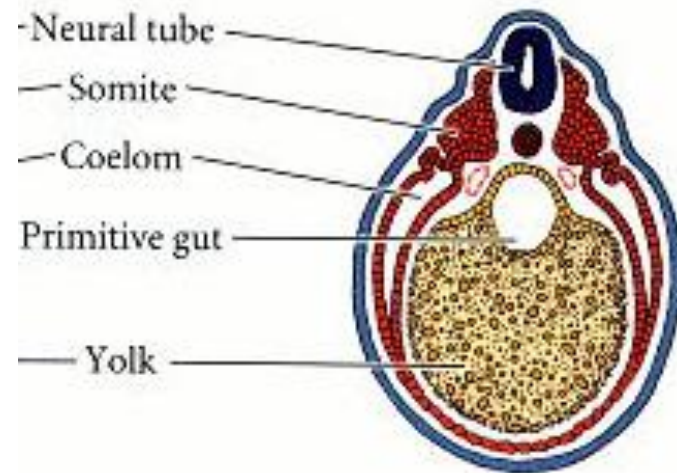
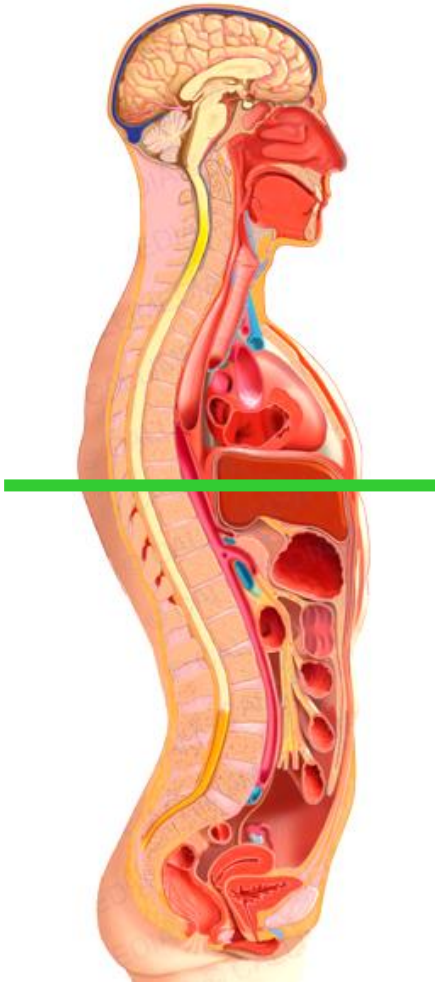
2. Discoidal cleavage
Fish, reptiles, birds



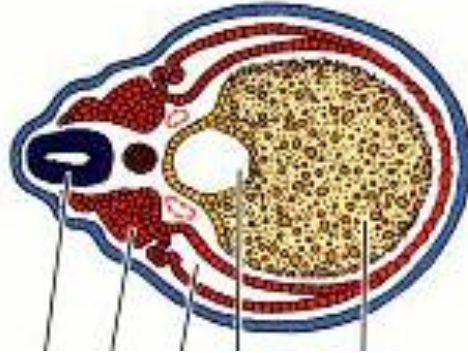
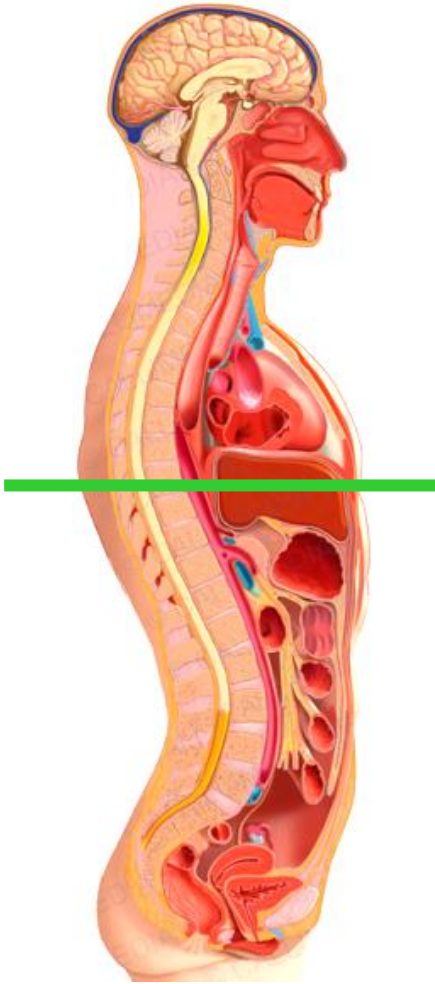
B. Centrolecithal (Yolk in center of egg)

Superficial cleavage
Most insects





FROG EMBRYO



Mecanismos del clivaje

- 1 - ¿Cómo pueden dividirse tan rápido las blastómeras?**
- 2 - ¿Cómo se forma el blastocele?
- 3 - ¿Qué es la transición de la blástula media?

1 - ¿Cómo pueden dividirse tan rápido las blastómeras?

37.000 células en 43 horas



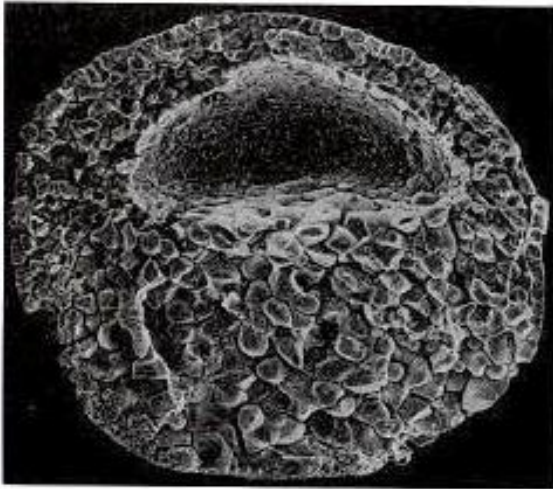
50.000 células en 12 horas



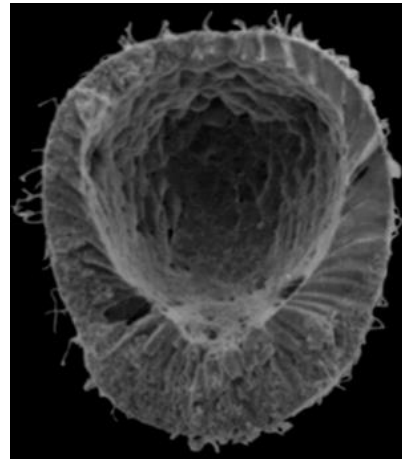
Mecanismos del clivaje

- 1 - ¿Cómo pueden dividirse tan rápido las blastómeras?
- 2 - **¿Cómo se forma el blastocele?**
- 3 - ¿Qué es la transición de la blástula media?

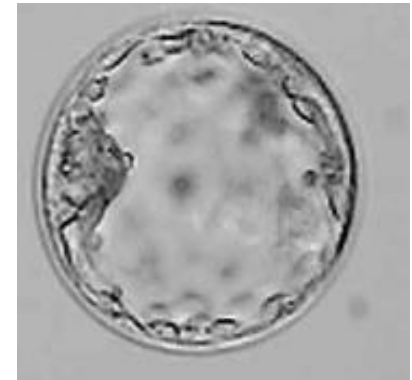
2 - ¿Cómo se forma el blastocele?



Anfibios



Equinodermos

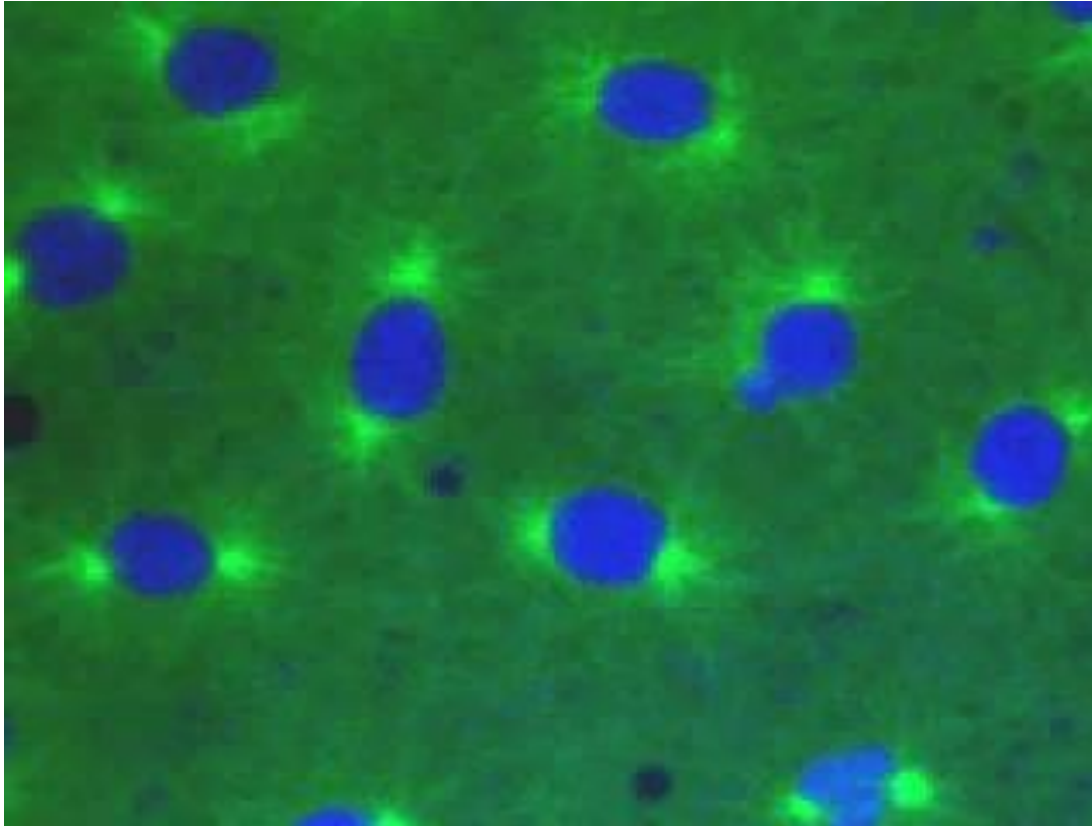


Mamíferos

Mecanismos del clivaje

- 1 - ¿Cómo pueden dividirse tan rápido las blastómeras?
- 2 - ¿Cómo se forma el blastocele?
- 3 - **¿Qué es la transición de la blástula media?**

3 - ¿Qué es la transición de la blástula media?



ADN
Microtúbulos

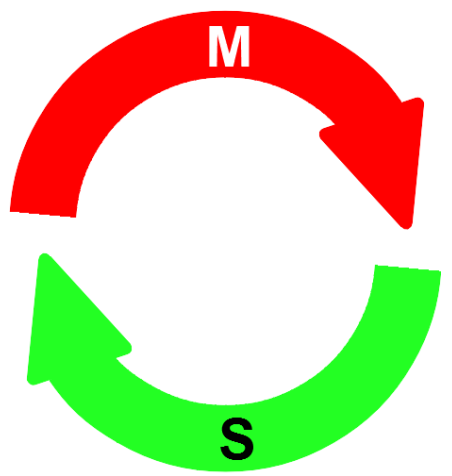
Divisiones sincrónicas y rápidas en un embrión temprano de la mosca *Drosophila melanogaster*

Mecanismos del clivaje

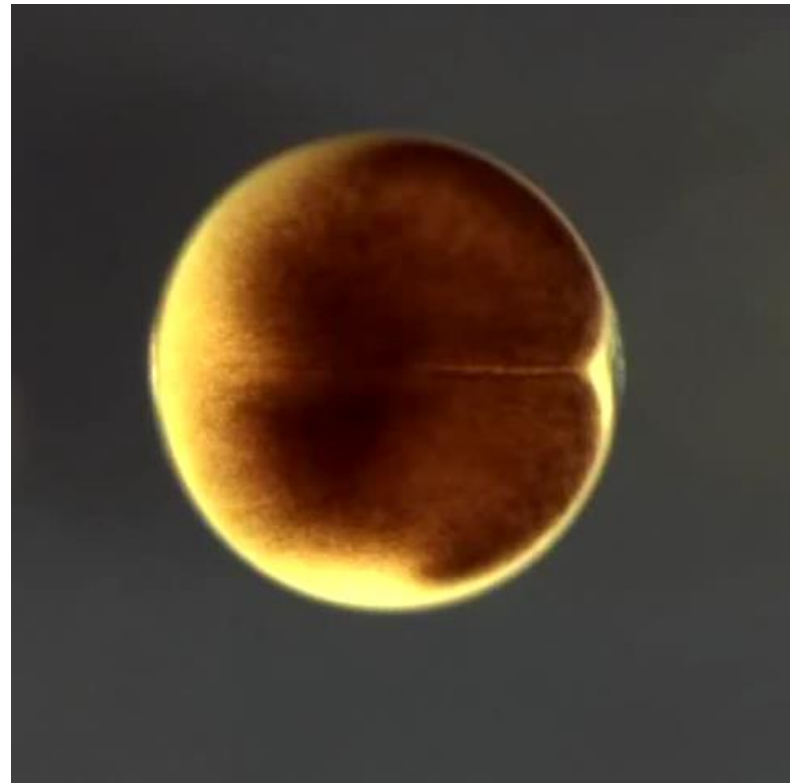
- 1 - ¿Cómo pueden dividirse tan rápido las blastómeras?
- 2 - ¿Cómo se forma el blastocele?
- 3 - ¿Qué es la transición de la blástula media?

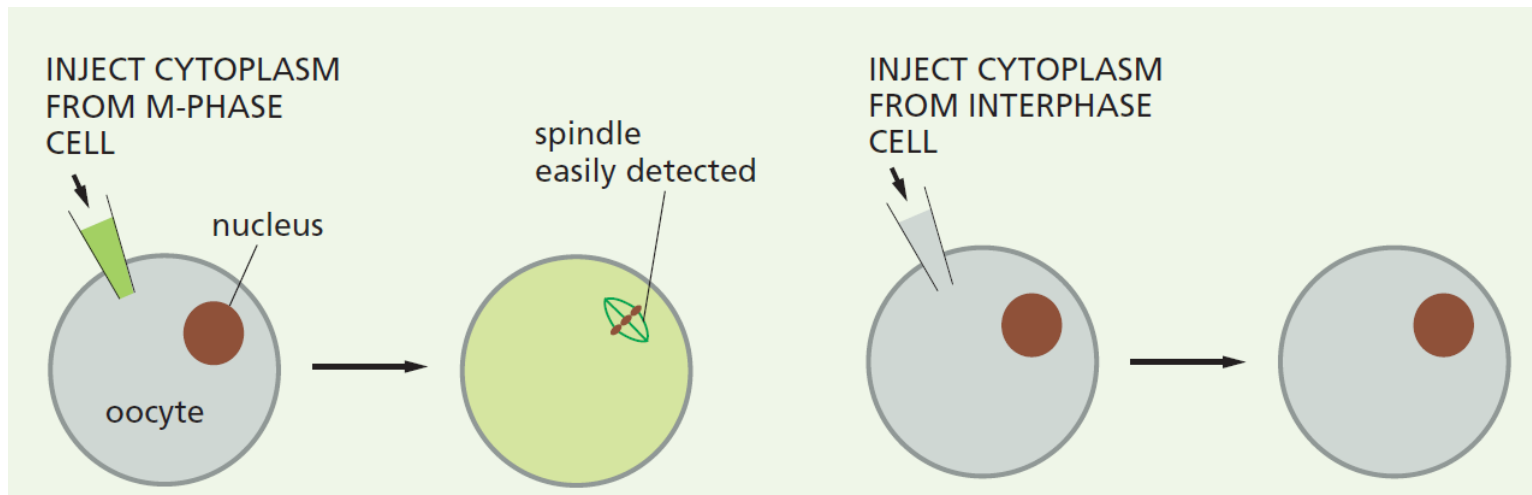
1 - ¿Cómo pueden dividirse tan rápido las blastómeras?

División sin crecimiento



Ciclo Bifásico



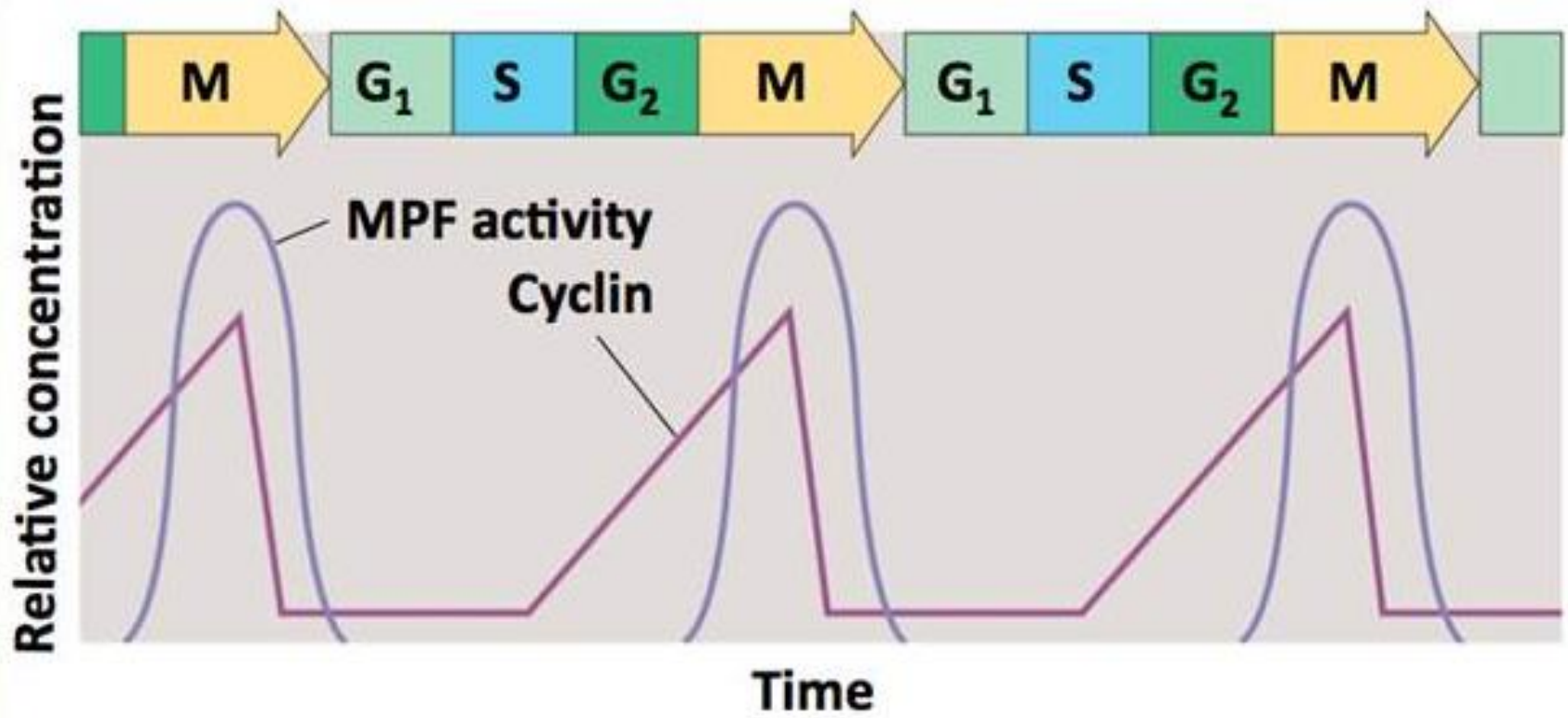


Entrada a
Fase M

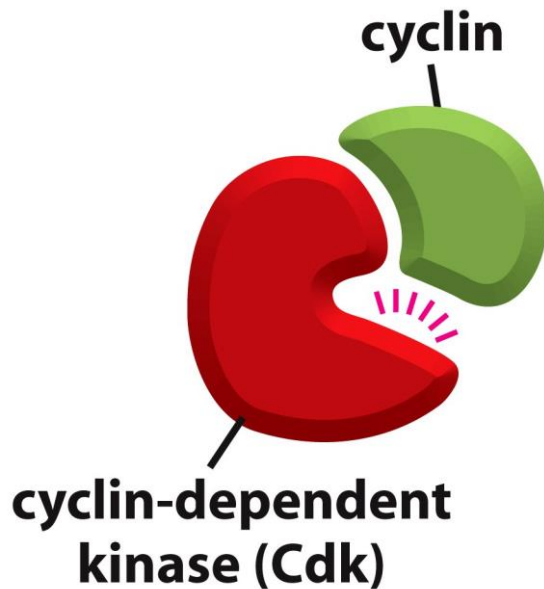
No entra a
Fase M

Factor Promotor de la Maduración (FPM)

Existen señales en el citoplasma que regulan el ciclo celular



Ciclinas y quinasas dependientes de ciclinas (CDKs)



Conservación evolutiva en eucariotas

ciclina + CDK = heterodímero activo



activación / inactivación
proteínas blanco (fosforilación)



entrada y salida coordinada
de las fases del ciclo

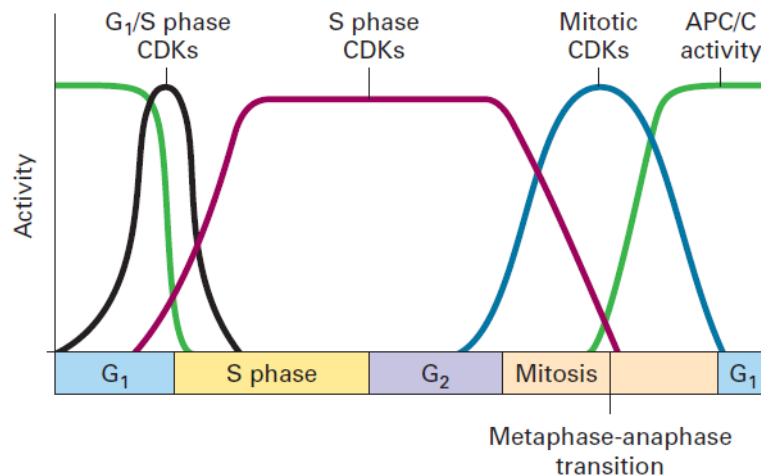
Las quinasas dependientes de ciclinas son activas únicamente cuando se encuentran formando complejo con su ciclina reguladora

Diferentes tipos de complejos ciclina-CDK inician diferentes eventos del ciclo celular

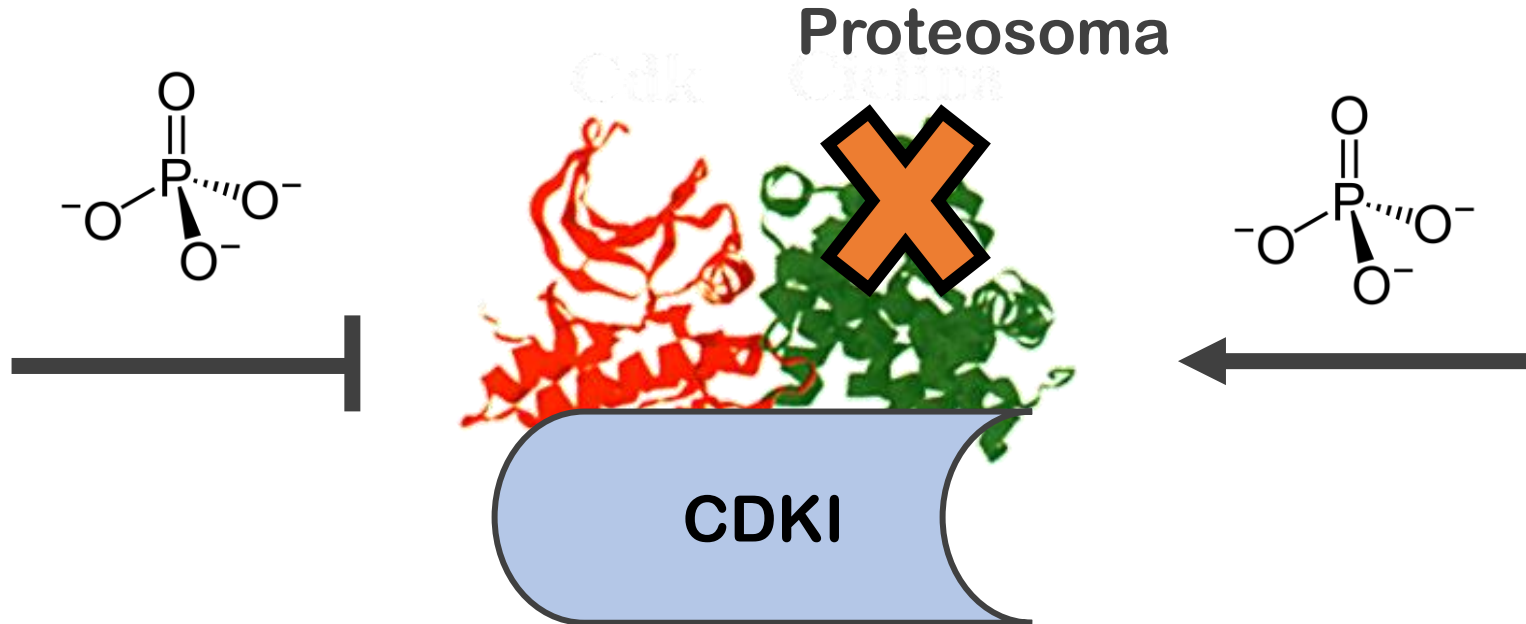
G1-CDK y G1/S CDK → entrada al ciclo celular

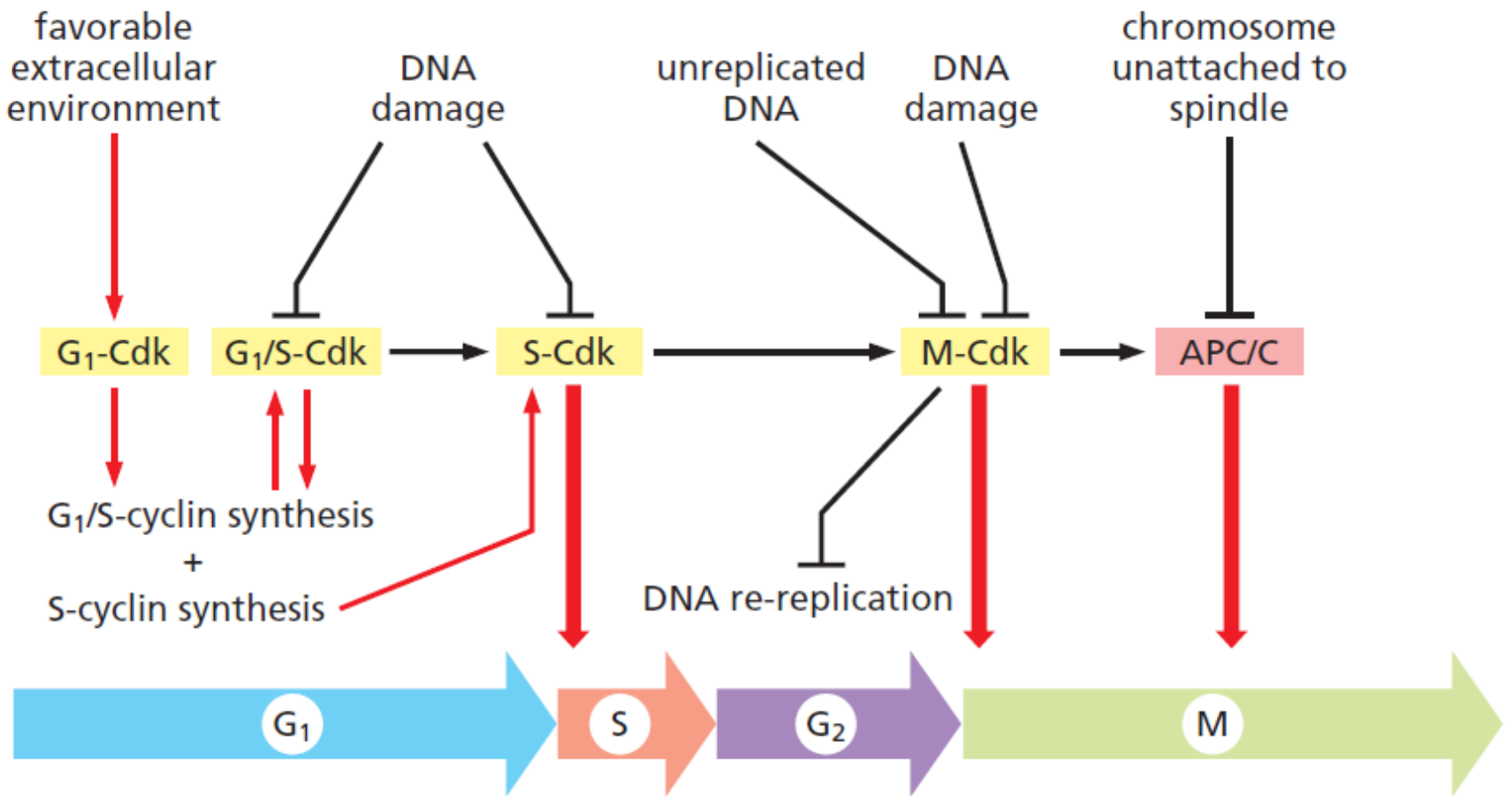
M-CDK → entrada a mitosis

Múltiples mecanismos son utilizados para asegurar que las diferentes CDKs estén activas únicamente en los estadios que promueven

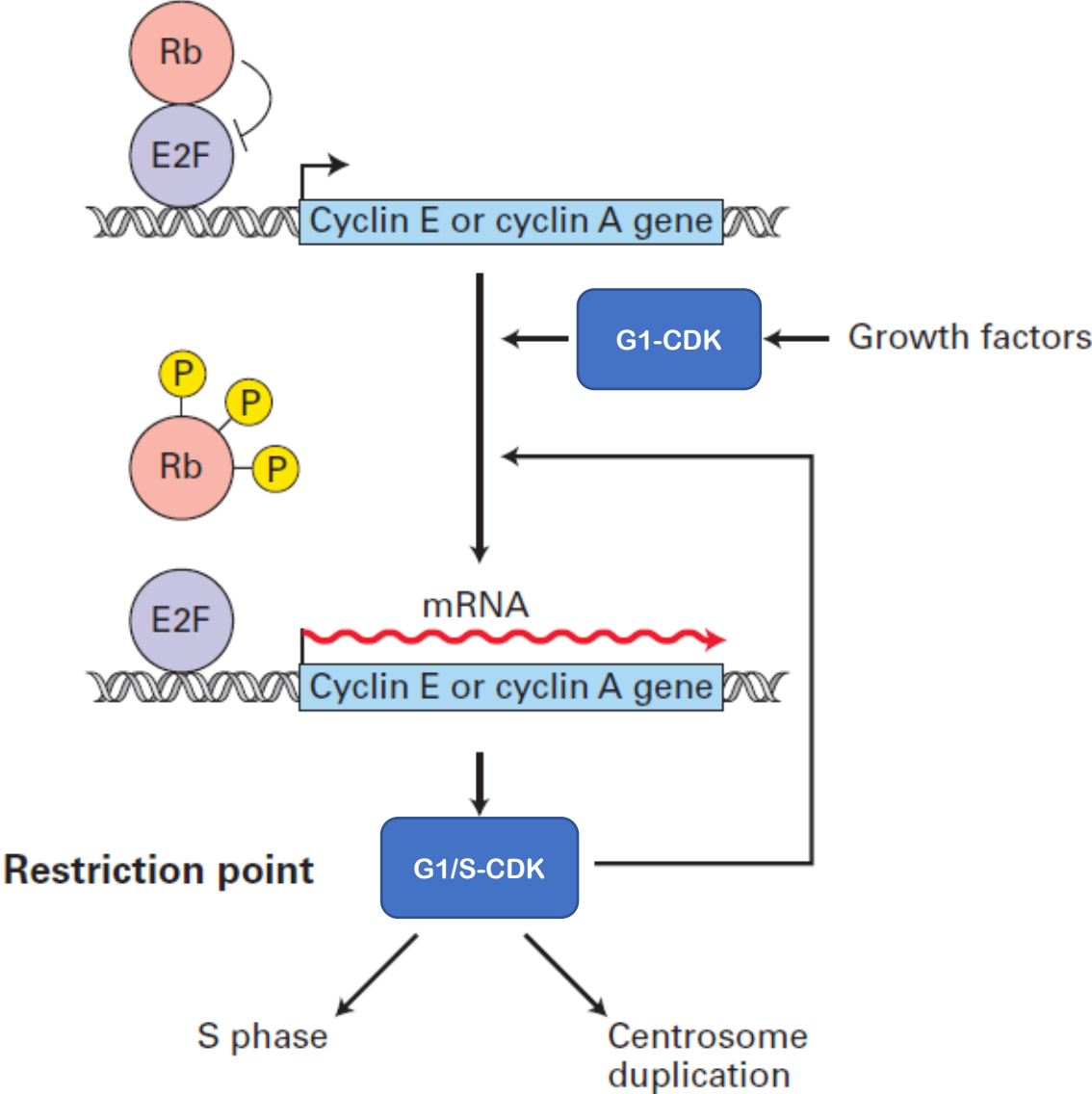


Múltiples vías de regulación de la actividad del complejo Ciclina-CDK

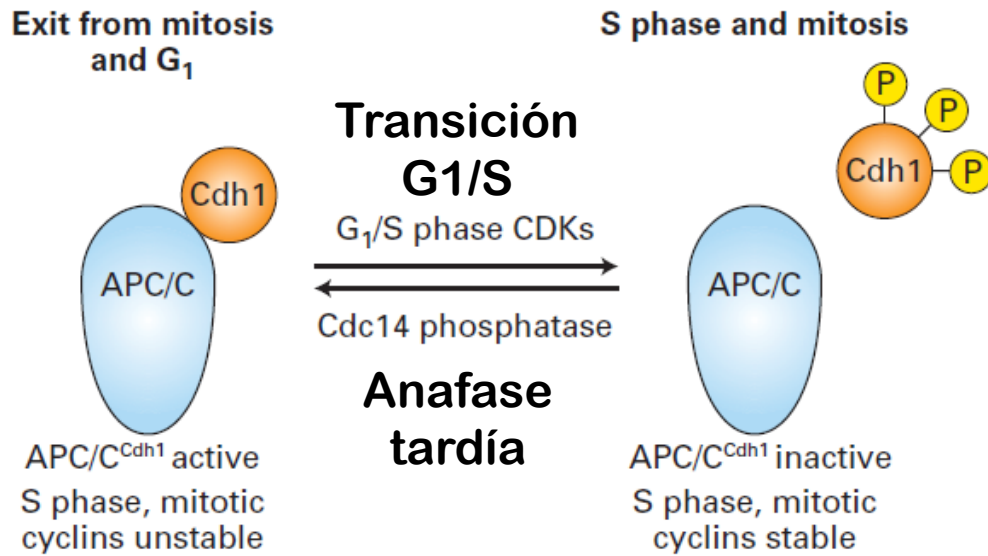




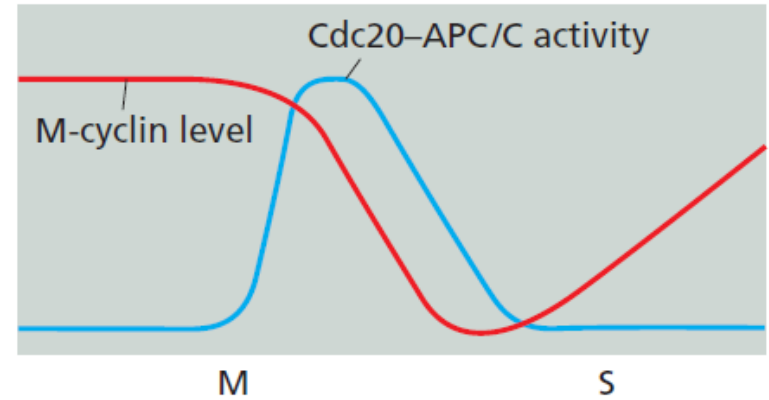
Entrada al ciclo



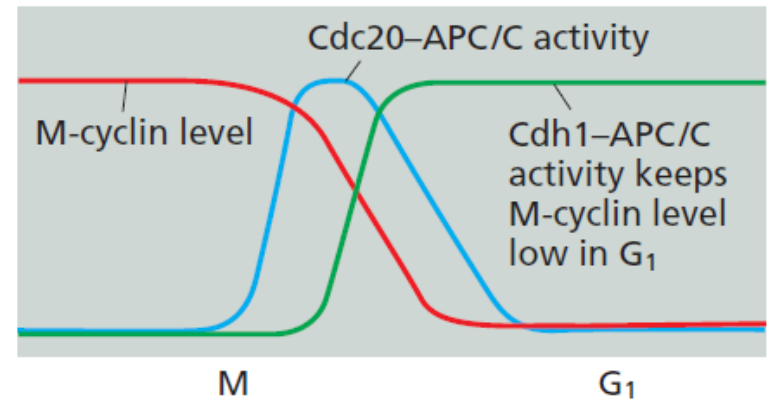
Entrada a fase S

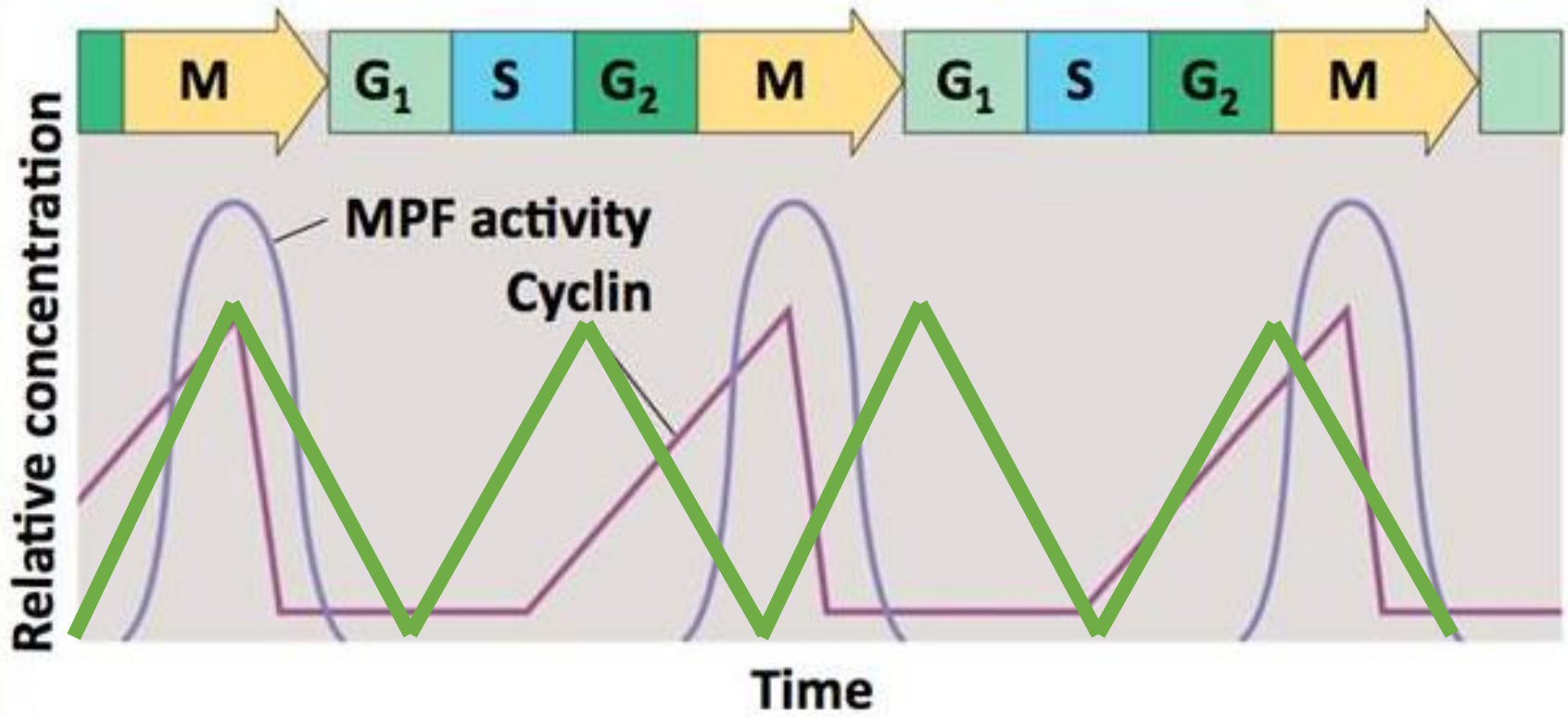


(A) embryonic cells with no G₁ phase

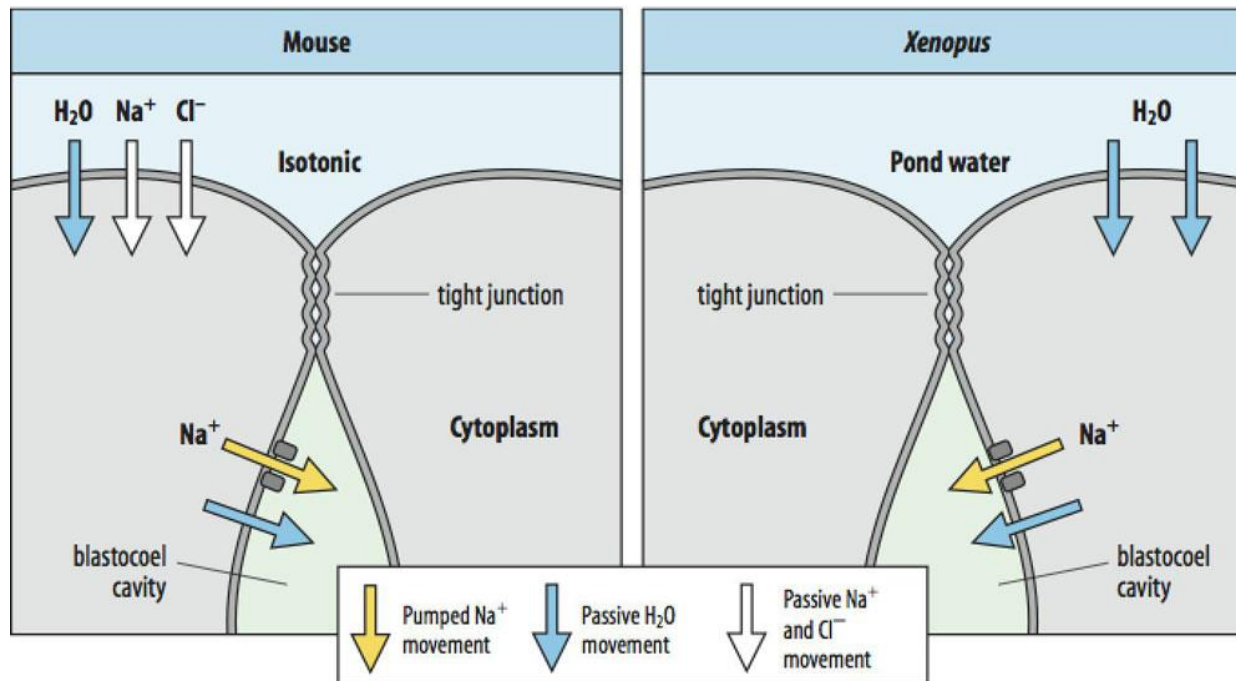


(B) cells with G₁ phase



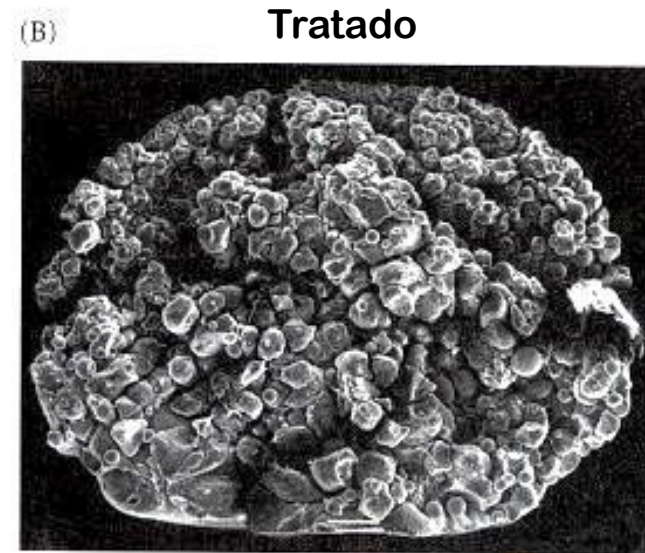
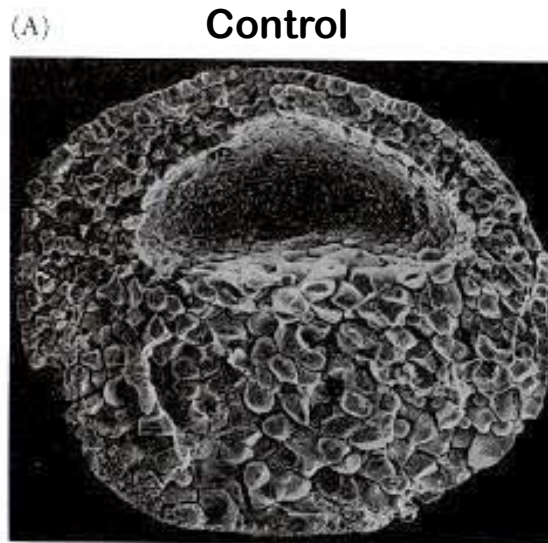


2 - ¿Cómo se forma el blastocelo?



A functional test for maternally inherited cadherin in *Xenopus* shows its importance in cell adhesion at the blastula stage

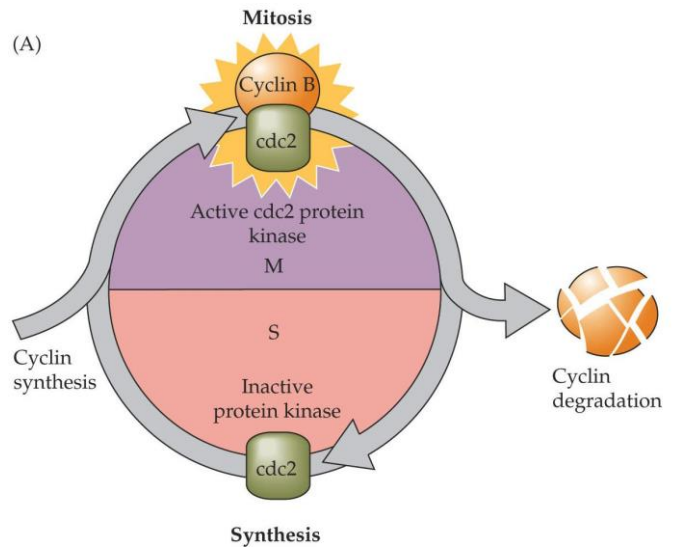
Janet Heasman¹, Dorit Ginsberg², Benjamin Geiger², Kim Goldstone¹, Travis Pratt¹, Chikako Yoshida-Noro¹ and Chris Wylie¹



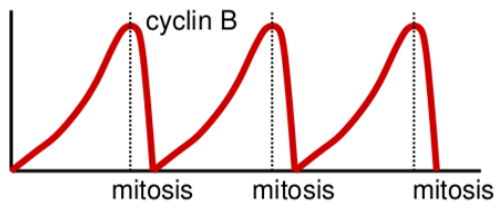
ARNm Cadherina

3 - ¿Qué es la transición de la blástula media?

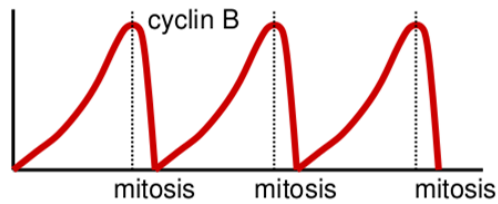
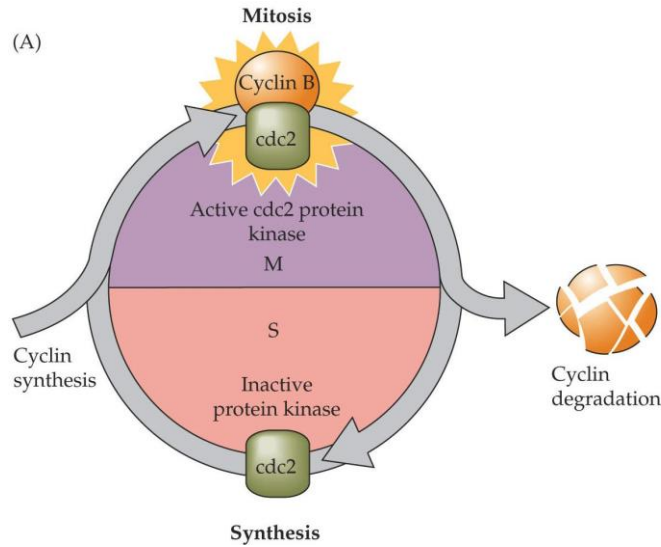
Segmentación



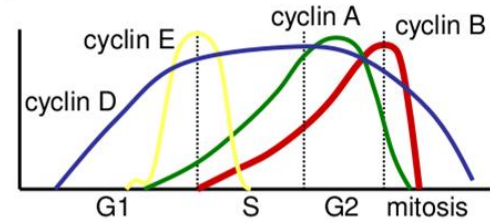
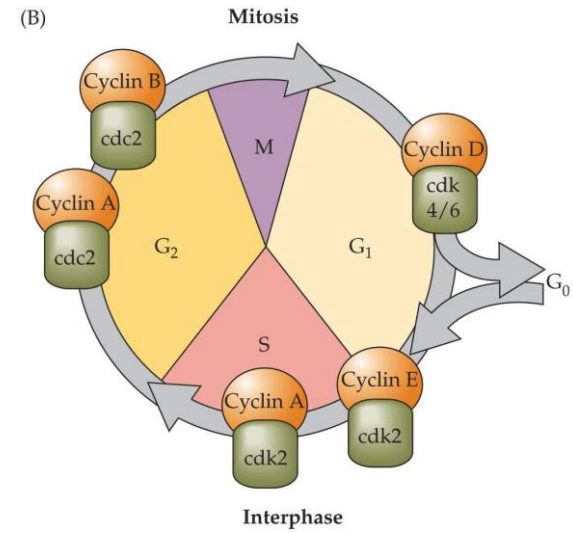
Presencia/degradación de Ciclina B controlado por proteínas citoplasmáticas del huevo
Clivaje temprano bajo control materno



Segmentación

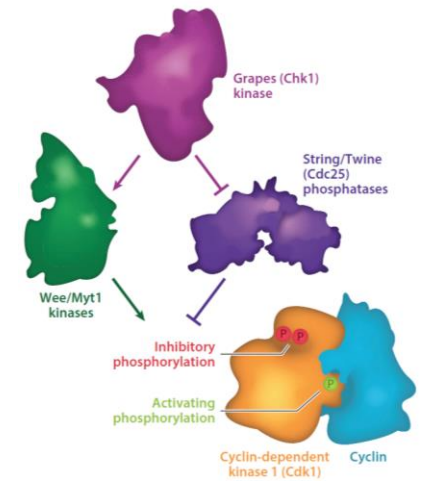
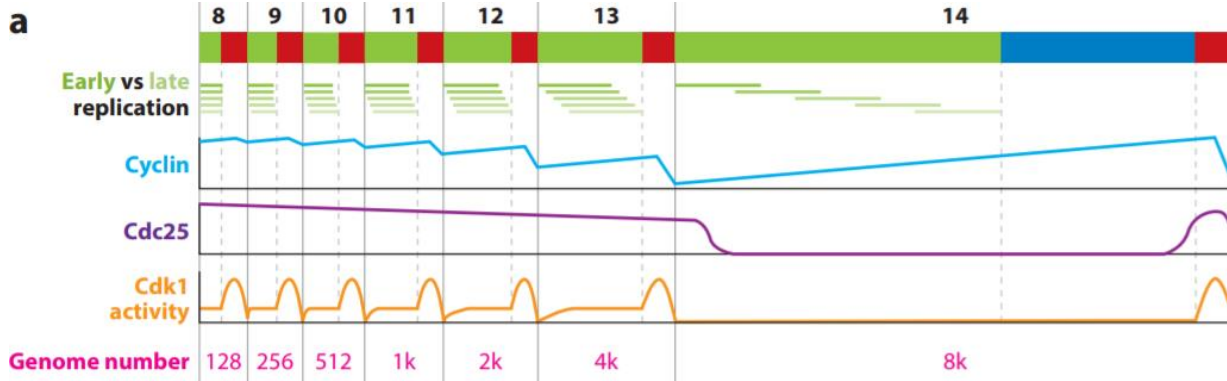
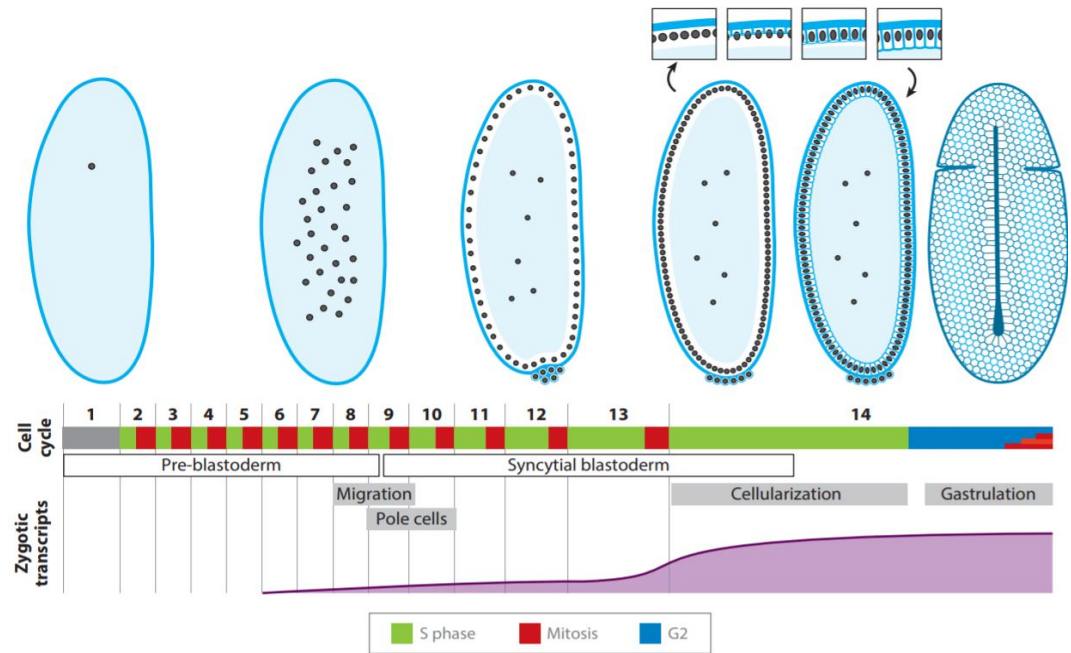


Post-transición de la blastula media



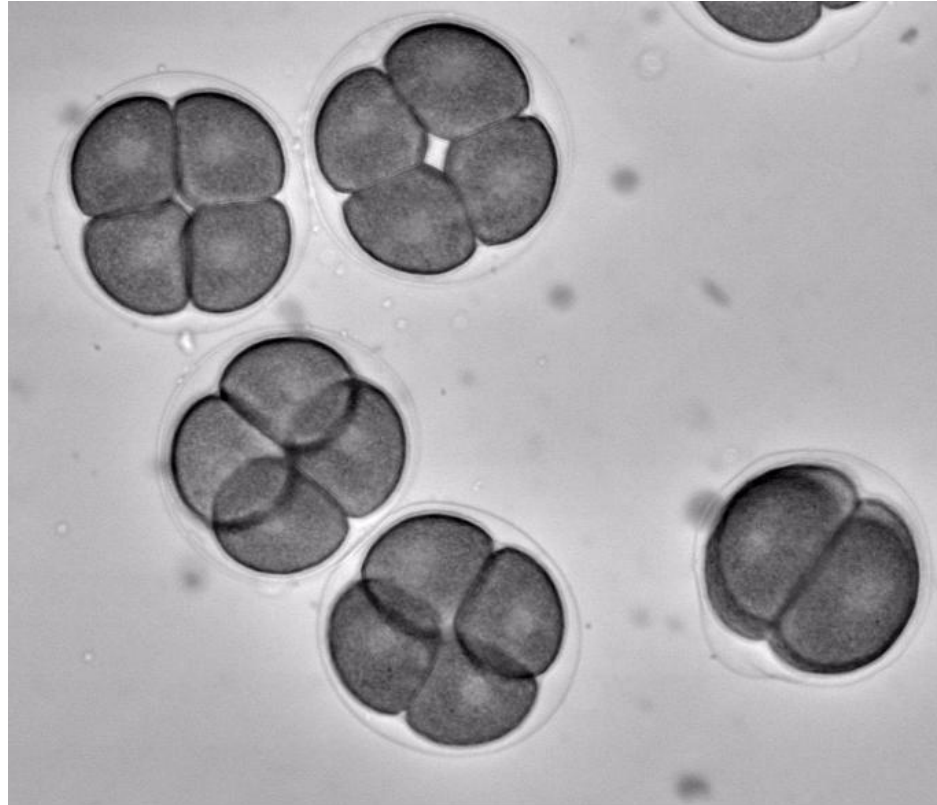
From Egg to Gastrula: How the Cell Cycle is Remodeled During the *Drosophila* Mid-Blastula Transition

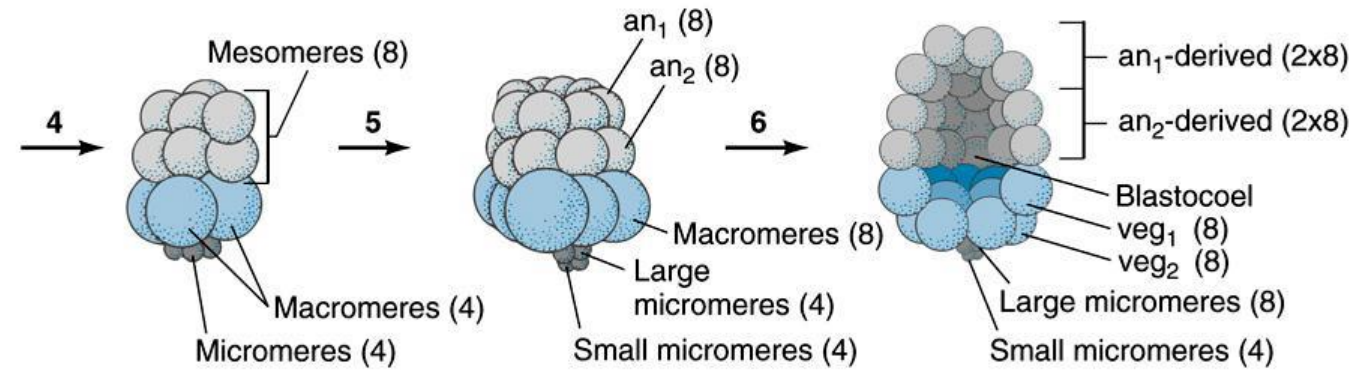
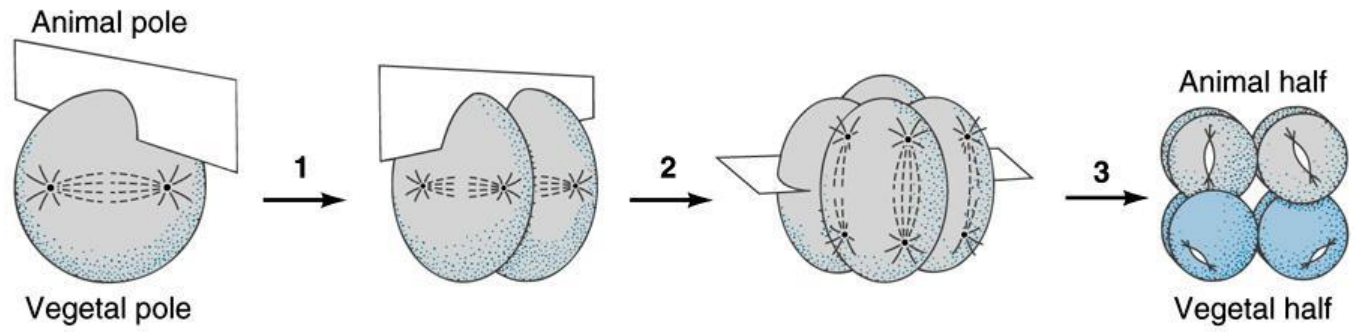
Jeffrey A. Farrell¹ and Patrick H. O'Farrell²

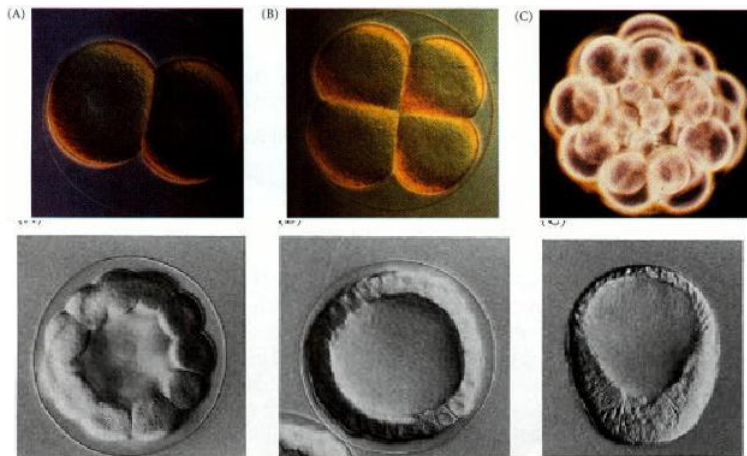
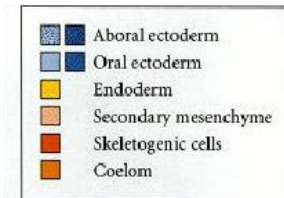
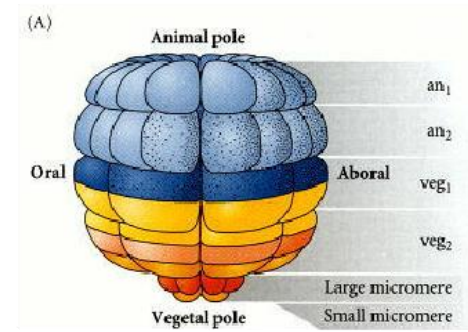
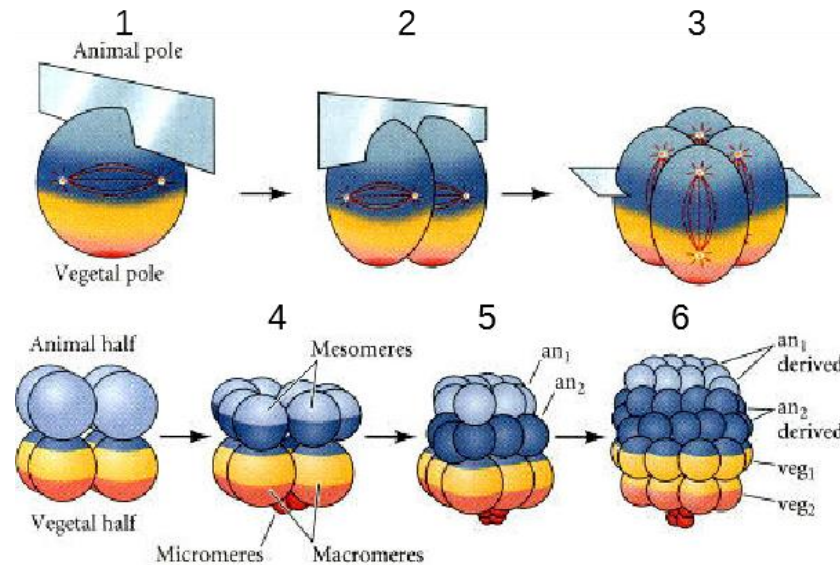


Ejemplos patrones de segmentación

Clivaje holoblástico radial: equinodermos

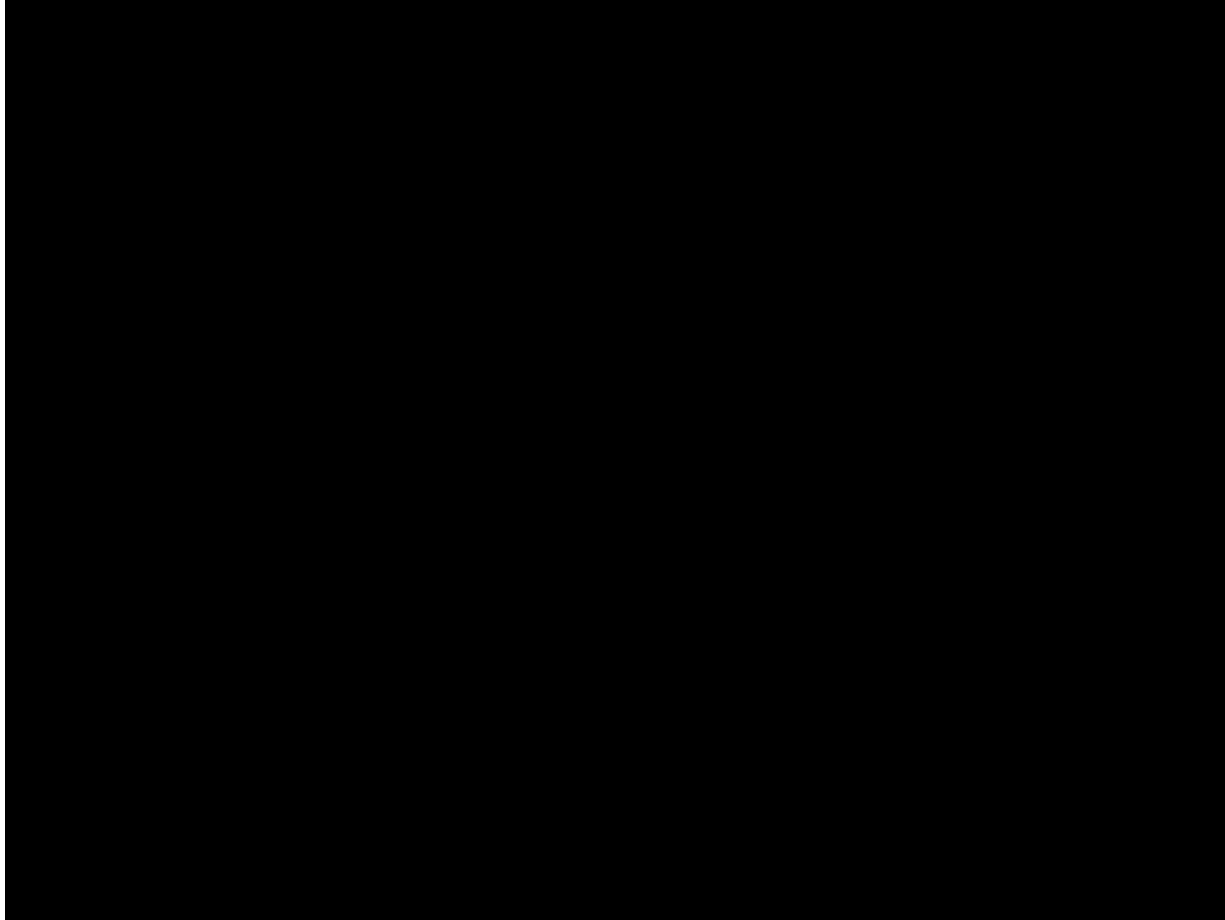


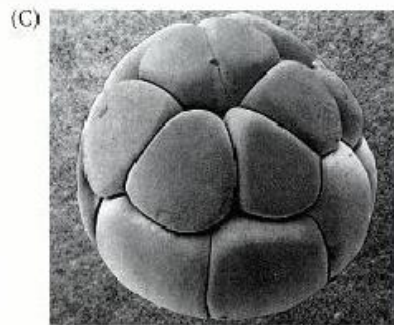
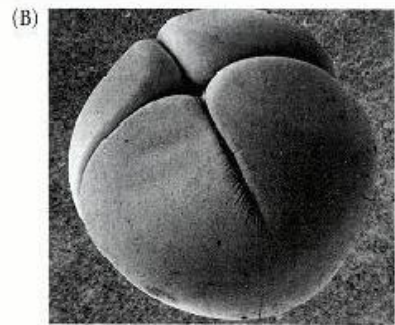
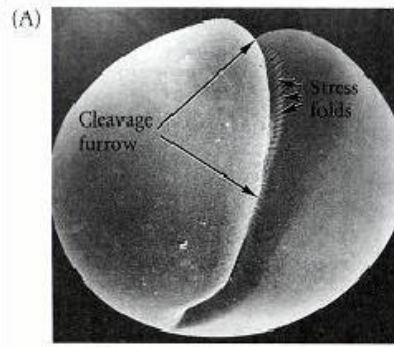
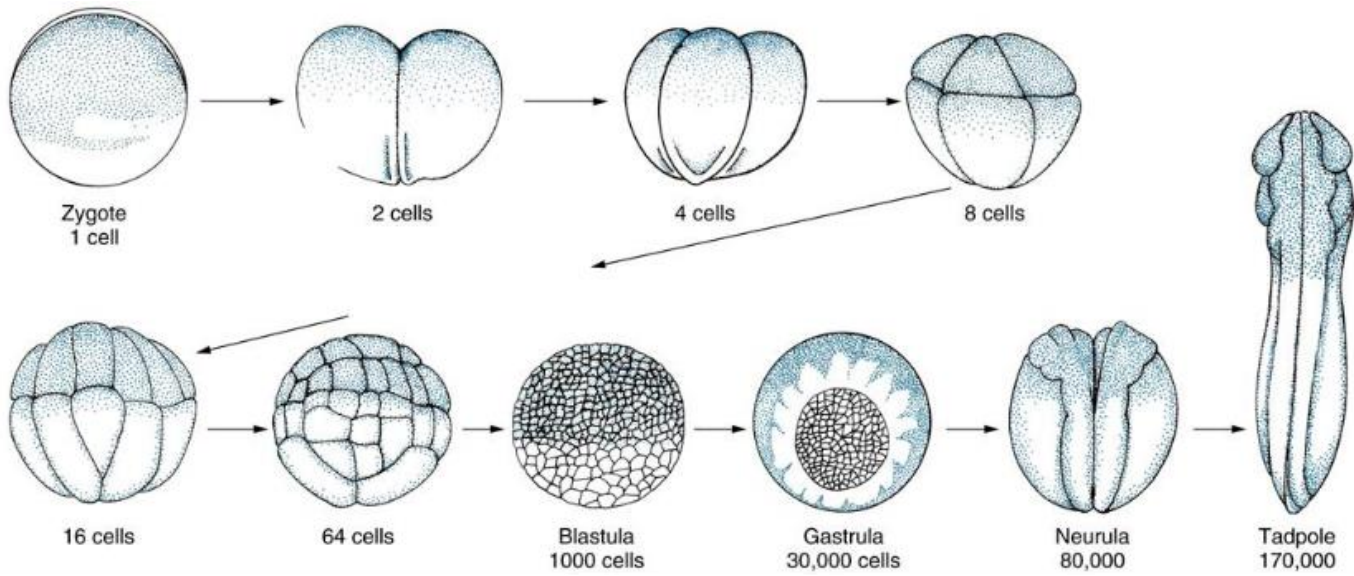




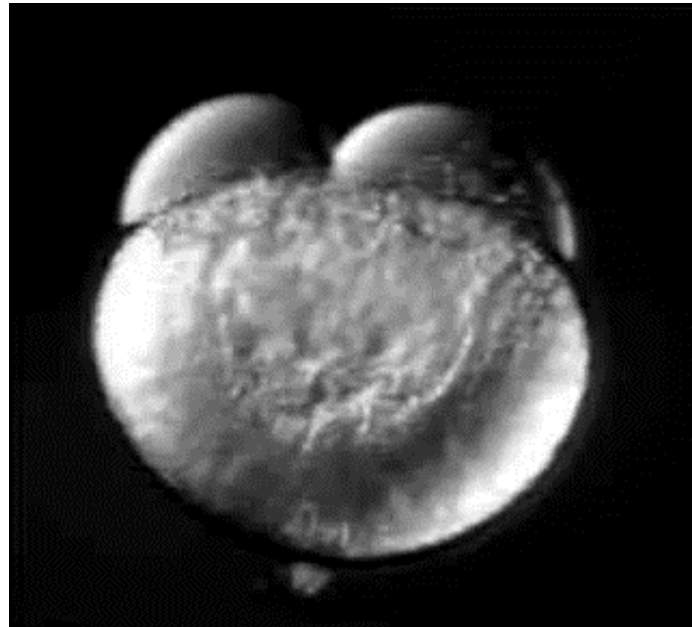
Blástula 120 células

Clivaje holoblástico radial: anfibios

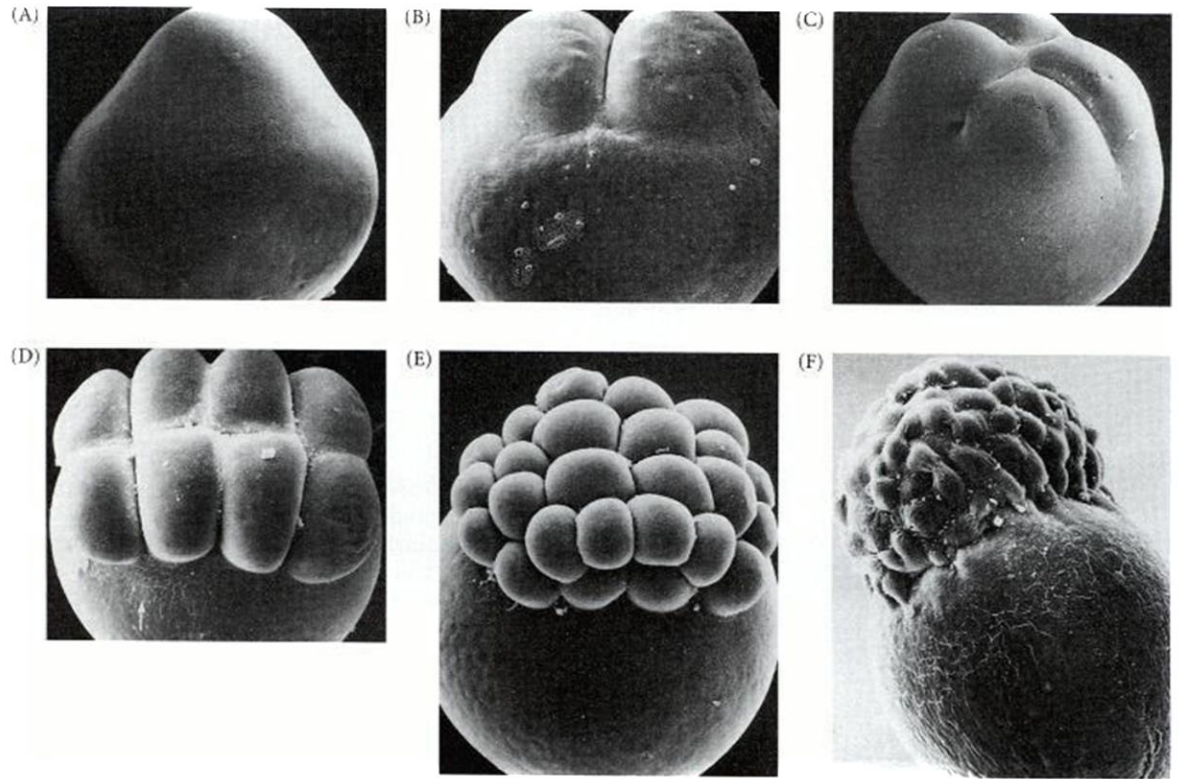




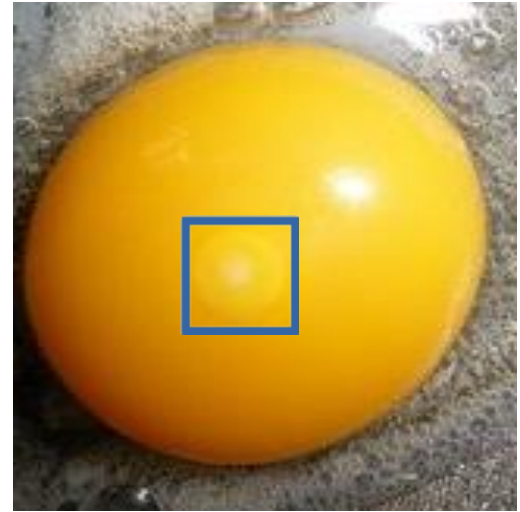
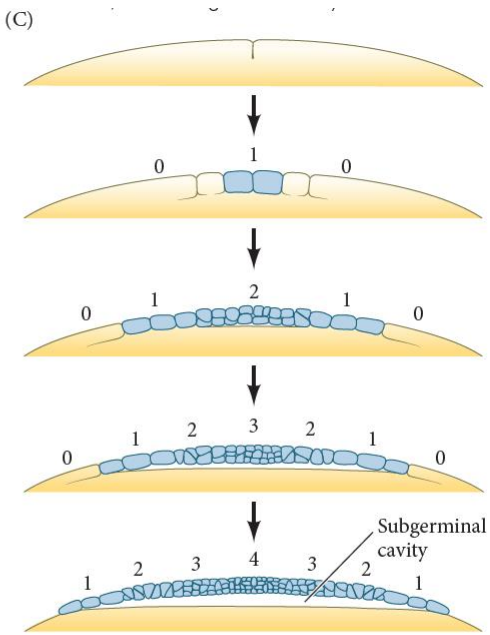
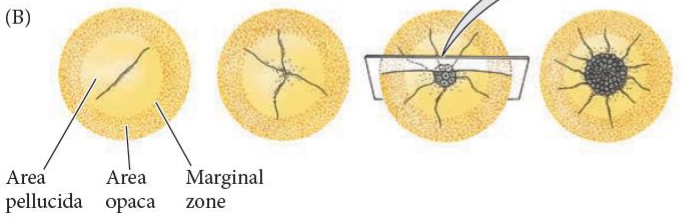
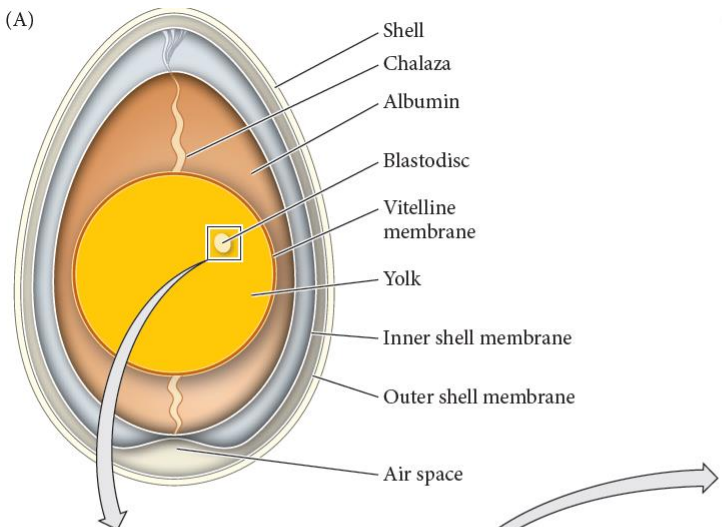
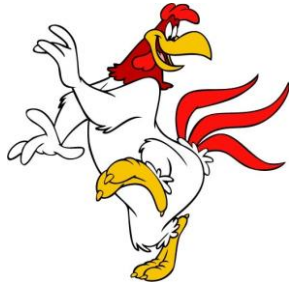
Clivaje meroblástico discoidal: peces teleósteos



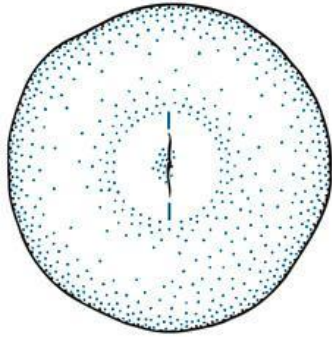
Huevo
telolecito



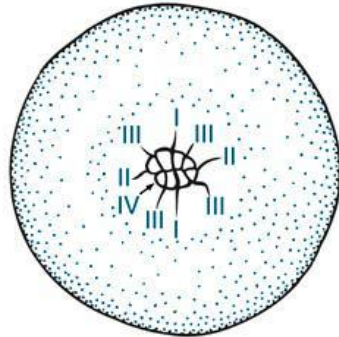
Clivaje meroblástico discoidal: aves



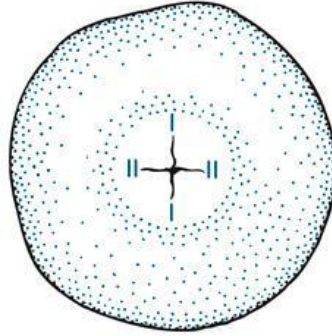
2-3 mm



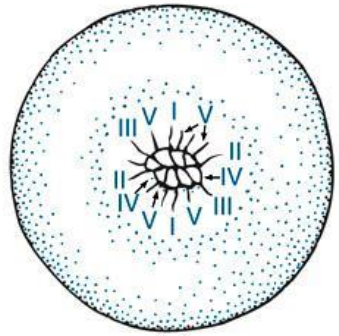
(a)



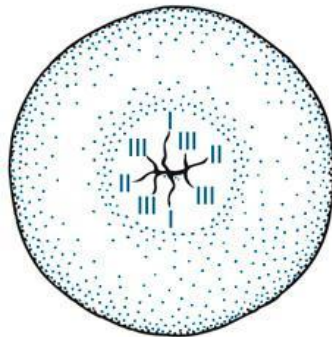
(d)



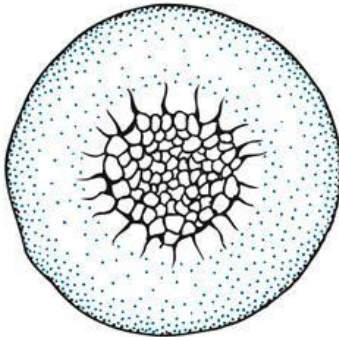
(b)



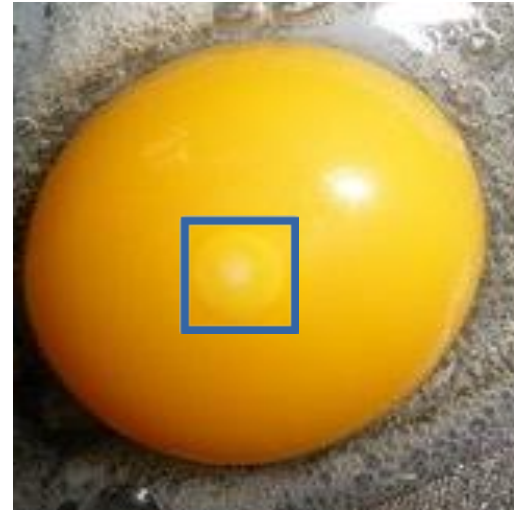
(e)



(c)



(f)



2-3 mm

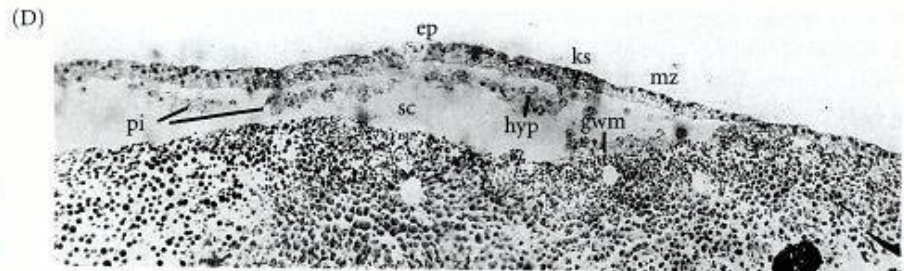
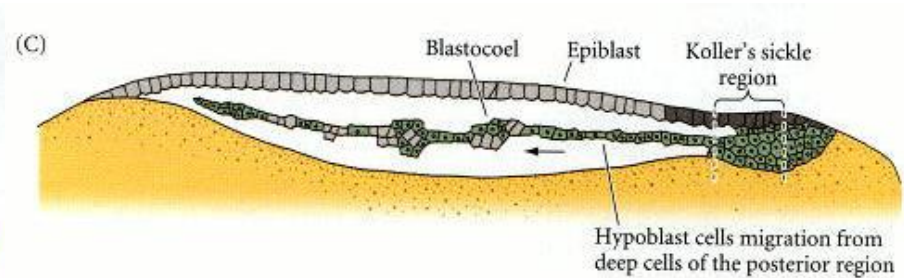
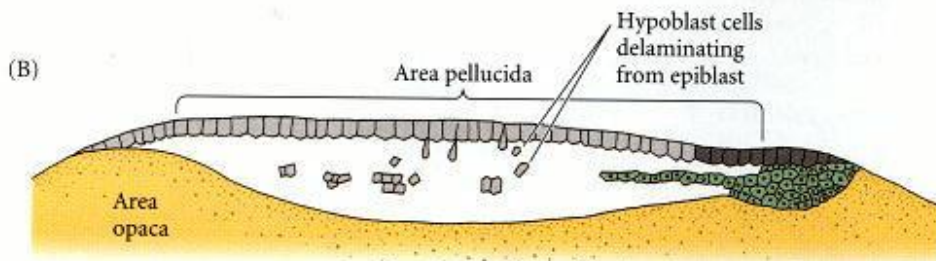
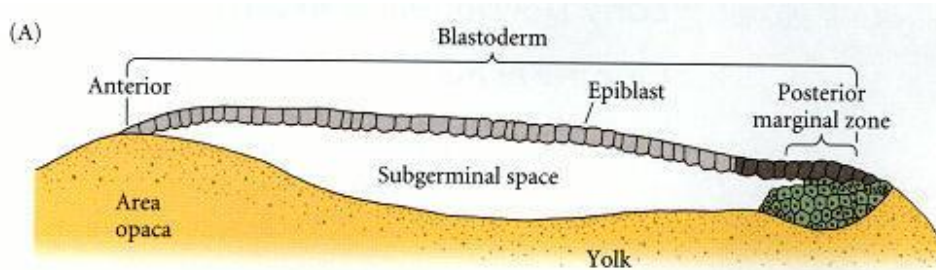


Cleavage

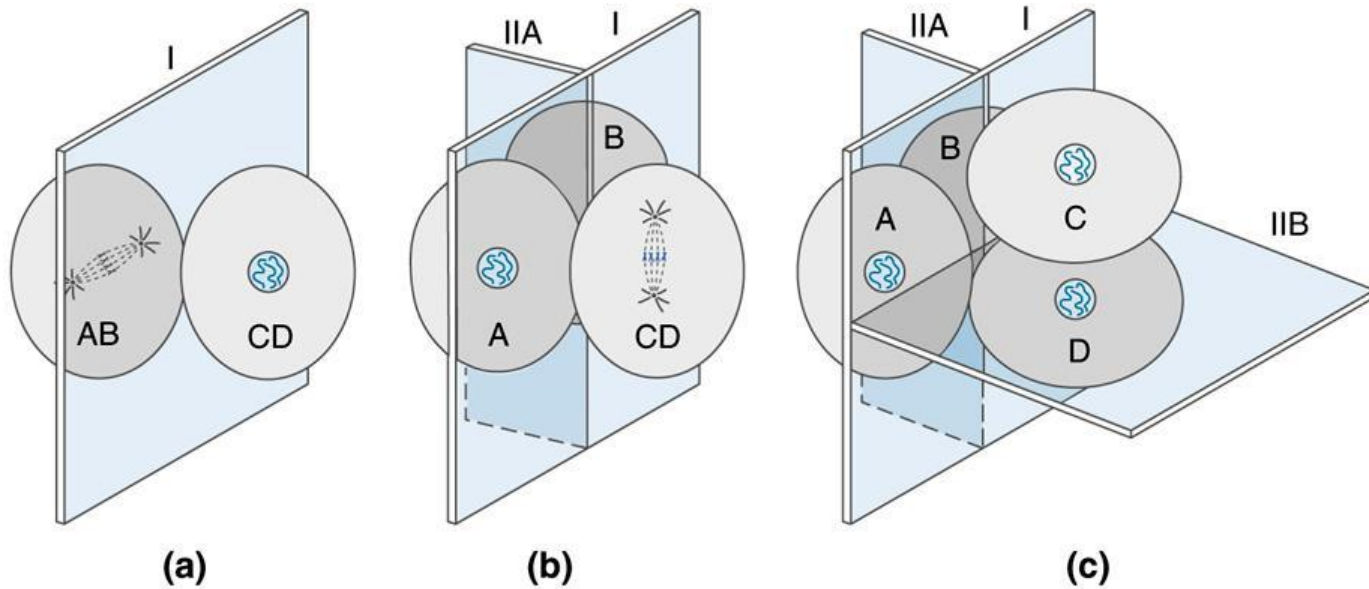
- Cellularization
- Maternal determinants
- ZGA & MBT
- Layer increase

Area pellucida formation

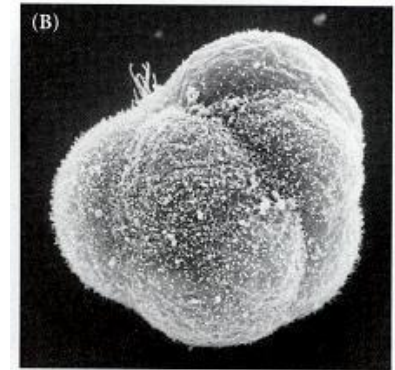
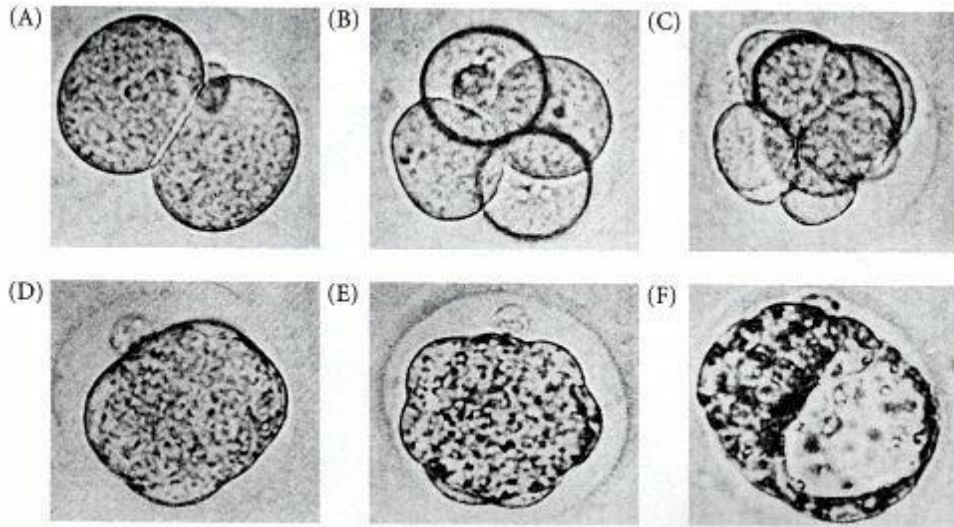
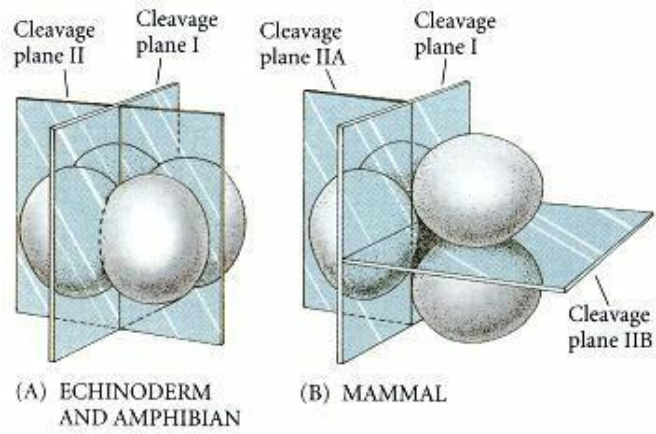
- Anterior-posterior polarity
- Layer reduction
- Lineage specification
- Yolk syncytium



Clivaje holoblástico rotacional: mamíferos

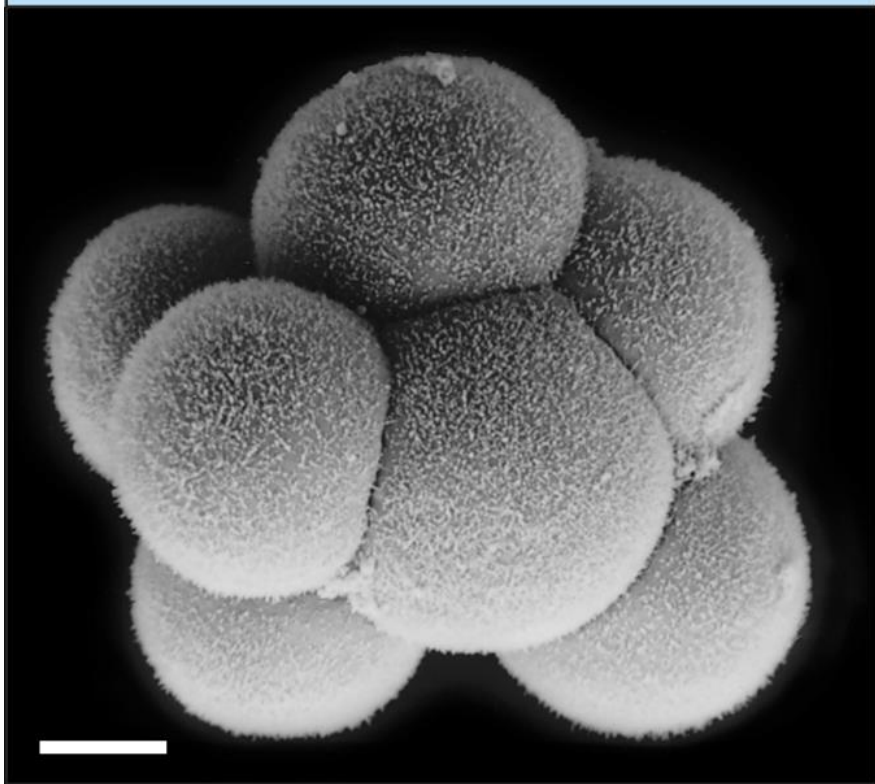


No presentan transición de la blástula media

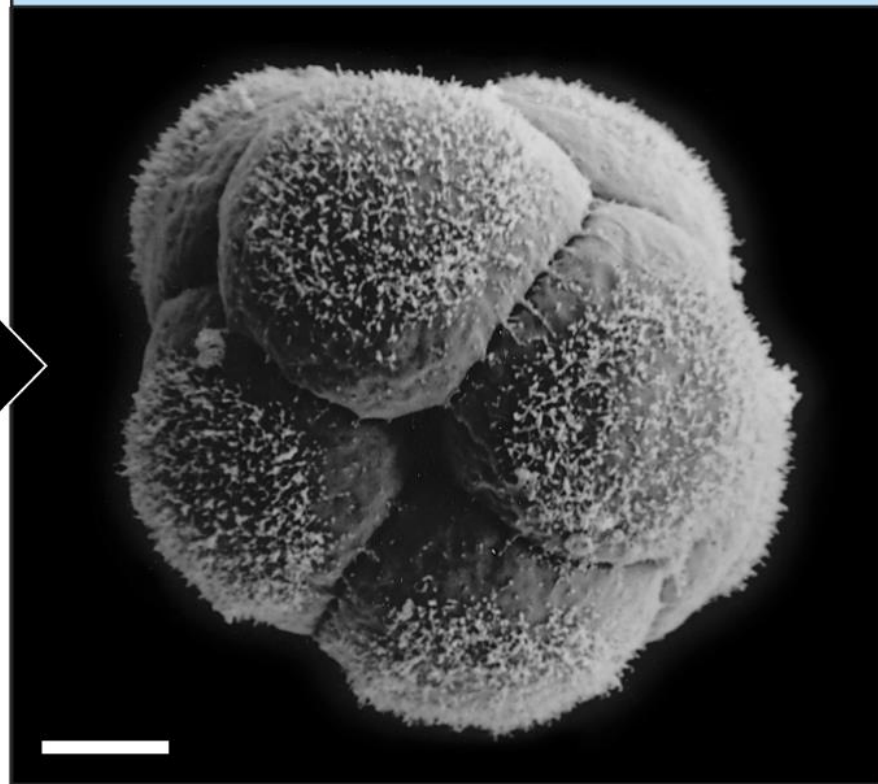


12-24 horas duración cada ciclo

Eight-cell stage



Compaction





Danae, Gustav klimt (1907)