

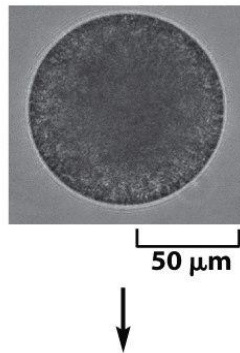
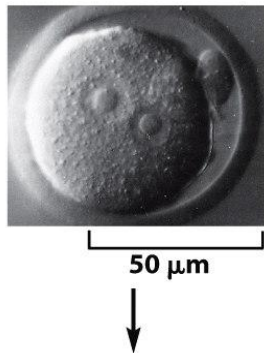
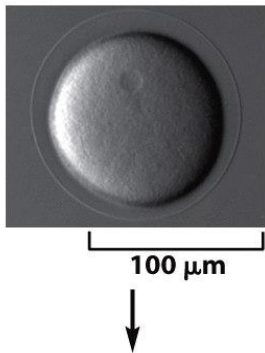
分子細胞修飾学研究室

since April, 2006

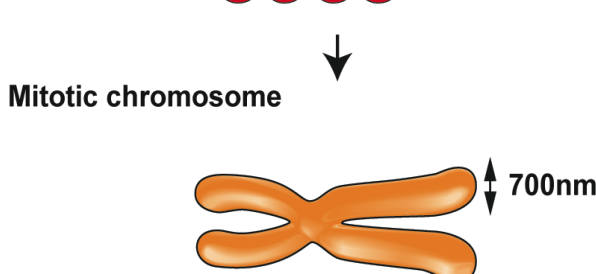
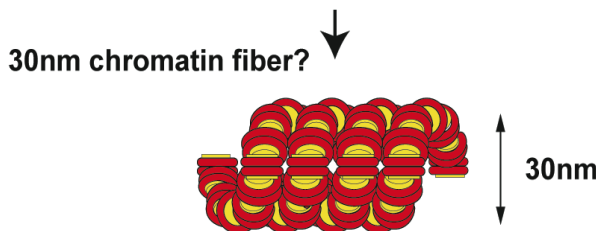
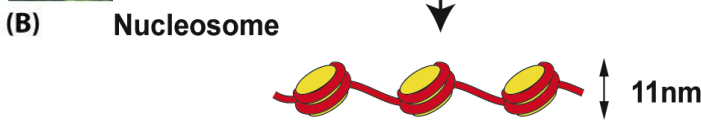
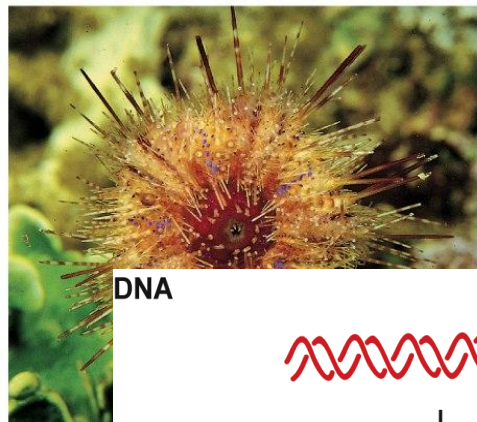


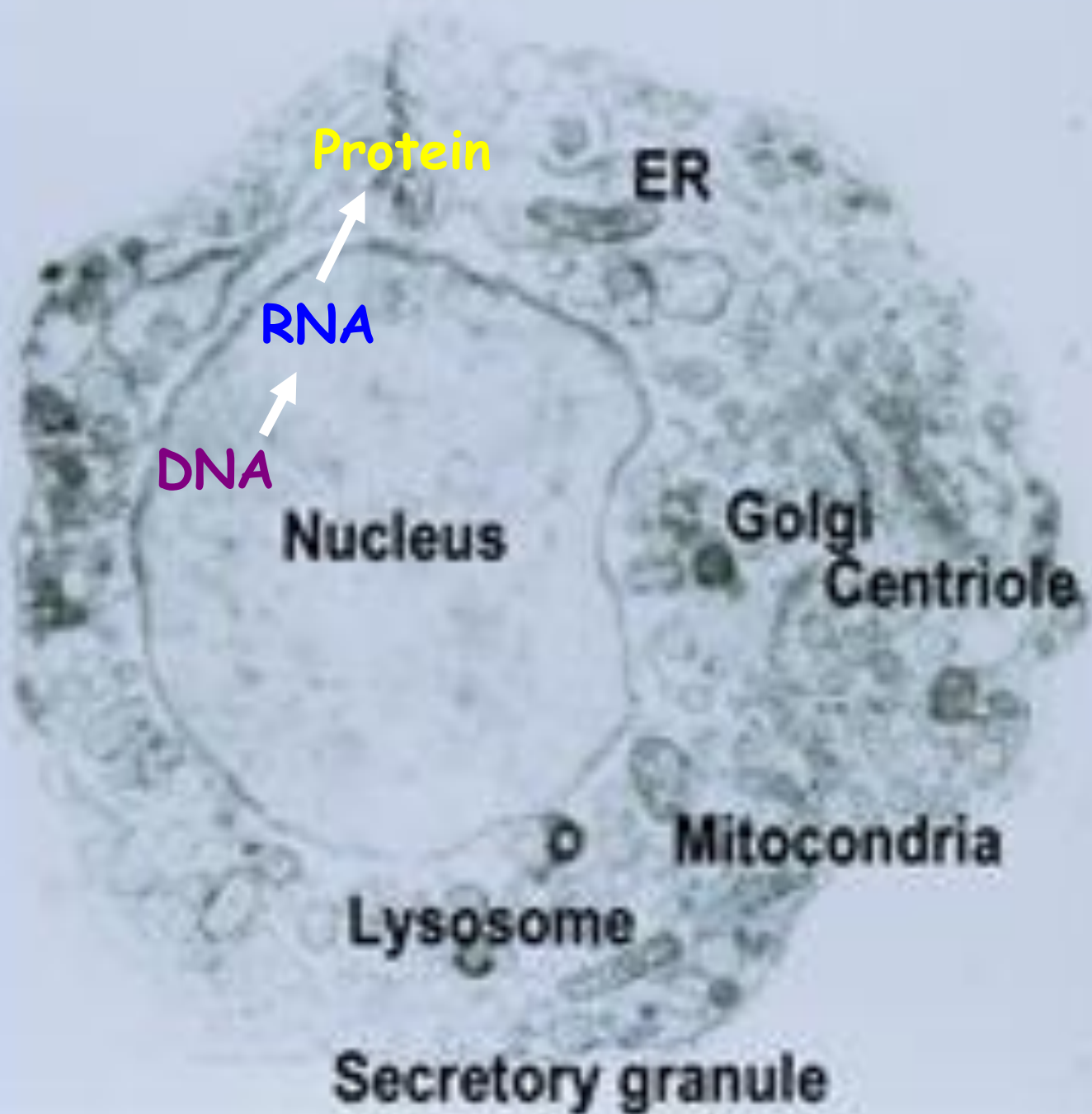
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関	●				
橋口	●			●	
河田					
後藤	●				
山田	●				
吉開	●				
青藤 (雅)	●				●
里岡	●				
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Mol. Biol. Cell
5th ed.より





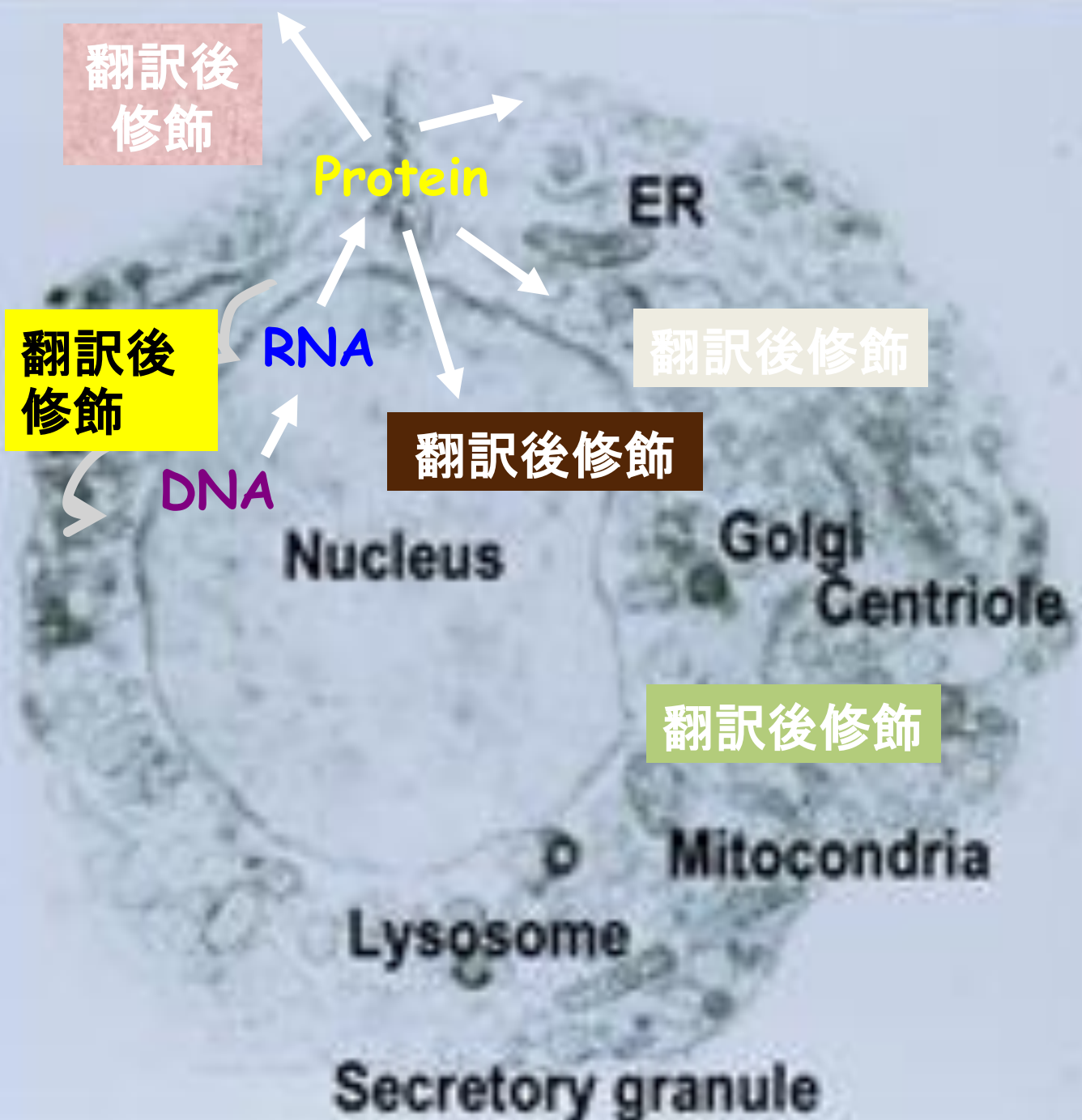
Protein
タンパク質

20種類の
アミノ酸で構成
されている

Table 2. Amino acids and amino acid derivatives in proteins. The following symbols are used to identify certain classes of derivatives: [] indicates derivatives, the existence of which is based on indirect evidence; italics indicate glycosylamino acids. The selection of the references in the table is rather arbitrary and does not properly acknowledge the individuals who discovered the different derivatives; an attempt was made to include the most recent research articles and reviews rather than the original reports. An attempt has been made to follow the nomenclature rules recommended by the IUPAC Commission on the Nomenclature of Organic Chemistry and the IUPAC-IUB Commission of Biochemical Nomenclature. Abbreviation, ADP, adenosine diphosphate.

Primary amino acids	Secondary (derived) amino acids
Alanine	<i>N</i> -Acetylalanine (19); <i>N</i> -methylalanine (32)
Arginine	<i>N</i> ^ω -Methylarginine (33); <i>N</i> ^ω , <i>N</i> ^ω -dimethylarginine (34); <i>N</i> ^ω , <i>N</i> ^{ω'} -dimethylarginine (35); ADP-ribosylarginine (36); citrulline (37), ornithine (38); arginyl-protein* (13)
Asparagine	Aspartic acid (16, 39); <i>N</i> ^ε -(<i>N</i> -acetylglucosaminyl)asparagine (10, 40); <i>N</i> ^ε (β-aspartyl)lysine† (41)
Aspartic acid	Aspartic α-amide (42); <i>N</i> -acetylaspargic acid (43); [<i>O</i> ⁴ -phosphonoaspartic acid] (44)
Cysteine	Cystine†, [<i>S</i> -mercaptocysteine] (45); <i>S</i> -galactosylcysteine (46); <i>S</i> -glucosylcysteine (47); <i>S</i> -cysteinyl-heme (48); 8α-(<i>S</i> -cysteinyl) flavin thiohemiacetal (49); [dehydroalanine]‡ (50)
Glutamic acid	Glutamic α-amide (42); γ-carboxyglutamic acid (51); γ-methylglutamic acid (52)
Glutamine	Glutamic acid (16); glutaminamide (53); pyroglutamic acid (54); <i>N</i> ^ε -(γ-glutamyl)lysine† (55)
Glycine	Glycinamide (56); <i>N</i> -acetyl glycine (19); <i>N</i> -formylglycine (57); <i>N</i> -glucuronylglycine (58)
Histidine	Histidinamide (59); π-methylhistidine (60); [π-phosphonohistidine] (61); [τ-phosphonohistidine] (61); 4-iodohistidine (62); 8α-(π-histidyl)flavin (49); 8α-(τ-histidyl)flavin (49)
Isoleucine	
Leucine	Leucyl-protein (14)
Lysine	<i>N</i> ^ε -Methyllysine (33, 34); <i>N</i> ^ε -dimethyllysine (33); <i>N</i> ^ε -trimethyllysine (33, 34); [<i>N</i> ^ε -phosphonolysine] (61); <i>N</i> ^ε -acetyllysine (63); <i>N</i> ^ε -(phosphopyridoxyl)lysine (64); <i>N</i> ^ε -lipoyllysine (65); <i>N</i> ^ε -biotinyllysine (66); <i>N</i> ^ε -murein-lysine (67); allysine (68); dehydrolysinonorleucine† (68); lysinonorleucine† (68); allysine aldol† (68); dehydroallysine aldol† (68); dehydromerodesmosine† (68); merodesmosine† (68); dihydrodesmosines† (68); desmosines† (68); tetrahydrodesmosines† (68); "compound 285" † (68); (allysine aldol)histidine† (69) δ-Hydroxylysine (Hyl); the following compounds are derivatives of Hyl and the δ has been omitted: <i>N</i> ^ε -trimethylhydroxylysine (70); <i>O</i> ^β -(β-D-galactosyl)hydroxylysine (71); hydroxyallysine (68); (dehydrohydroxylysino)norleucine† (68); hydroxylysinonorleucine† (68, 72); (dehydrohydroxylysino)hydroxynorleucine† (68); (hydroxylysino)hydroxynorleucine† (68); syndesine† (68); dehydrohydroxymerodesmosine† (68); (dehydrohistidino)hydroxymerodesmosine† (73); (hydroxyallysinealdol)histidine† (74)
Methionine	Methioninamide (42, 75); <i>N</i> -acetylmethionine (76); <i>N</i> -formylmethionine (77)
Phenylalanine	Phenylalaninamide (78); [β-hydroxyphenylalanine] (79); <i>O</i> ^β -glycosyl-β-hydroxyphenylalanine (79); phenylalanyl-protein* (14)
Proline	Prolinamide (80); [3,4-dihydroxyproline] (81); 4-hydroxyproline (4Hyp) (4, 82); 3-hydroxyproline (3Hyp) (4, 82); <i>O</i> ⁴ -arabino-sylhydroxyproline (83); <i>O</i> ⁴ -galactosylhydroxyproline (84)
Serine	Pyruvate (85); <i>N</i> -acetylserine (19, 30); <i>O</i> ^β -phosphoserine (86); <i>O</i> ^β (ADP-ribosyl-phosphono)serine (87); [<i>O</i> ^β -methylserine] (88); <i>O</i> ^β -(4'-phosphonopantetheine)serine (89); <i>O</i> ^β -xylosylserine (90); <i>O</i> ^β -mannosylserine (91); <i>O</i> ^β -(<i>N</i> -acetyl-galactosaminy)serine (92); <i>O</i> ^β -galactosylserine (93)
Threonine	[α-Ketobutyrate] (94); <i>N</i> -acetylthreonine (95); <i>O</i> ^β -phosphothreonine (86, 96); [<i>O</i> ^β -methylthreonine] (88); <i>O</i> ^β -fucosylthreonine (97); <i>O</i> ^β -mannosylthreonine (98); <i>O</i> ^β -(<i>N</i> -acetyl galactosaminy)threonine (92); <i>O</i> ^β -galactosylthreonine (93)
Tryptophan	
Tyrosine	Tyrosinamide (99); tyrosine <i>O</i> ⁴ -sulfate (100); 3-iodotyrosine (62); 3,5-diiodotyrosine (62); 3-chlorotyrosine (101-103); 3,5-dichlorotyrosine (103); 3-bromotyrosine (102, 103); 3,5-dibromotyrosine (102, 103); 5-bromo-3-chlorotyrosine (103); 3,5,3'-triodothyronine† (104); 3,5,3',5'-tetraiodothyronine† (104); 3,3'-bityrosine† (105); 3,3',5',3"-tertyrosine† (105); <i>O</i> ⁴ -adenylyltyrosine (106); <i>O</i> ⁴ -uridylyltyrosine (107); [β-hydroxytyrosine] (79); <i>O</i> ^β -glycosyl-β-hydroxytyrosine (79); [dihydroxyphenylalanine] (108); proteinylytyrosine* (15)
Valine	Valinamide (42); <i>N</i> -acetylvaline (109)

*These designations, aminoacyl-protein or proteinyly-amino acid, are used to list derivatives produced by the direct transfer of the aminoacyl moiety of aminoacyl-tRNA or of free amino acids to acceptor proteins. Since several amino acids are derived in these reactions, the derivatives have been listed under the amino acid that is transferred. †These derivatives constitute protein cross-links. ‡The in vivo precursor of dehydroalanine is unknown. Since dehydroalanine is known to be a product of alkali treatment of cystine in vitro, it has been tabulated as a derivative of cysteine.



タンパク質の
翻訳後修飾

- Chemicals
 Phosphorylation
 Acetylation
 Methylation
 Citrullination

- Proteins
 Ubiquitylation
 SUMOylation

ヒストンのシトルリン化によるクロマチン 脱凝縮と血液細胞（好中球）の分化

（成人T細胞白血病、敗血症、自己免疫、リュウマチ）

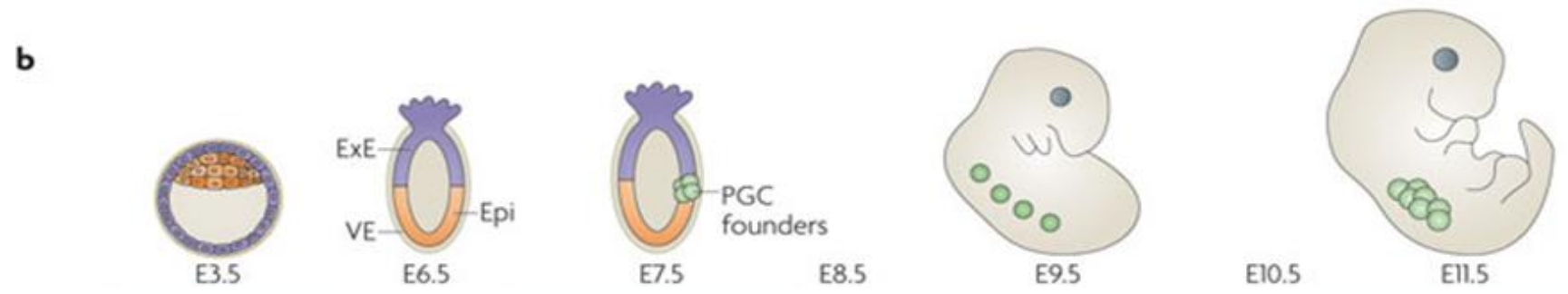
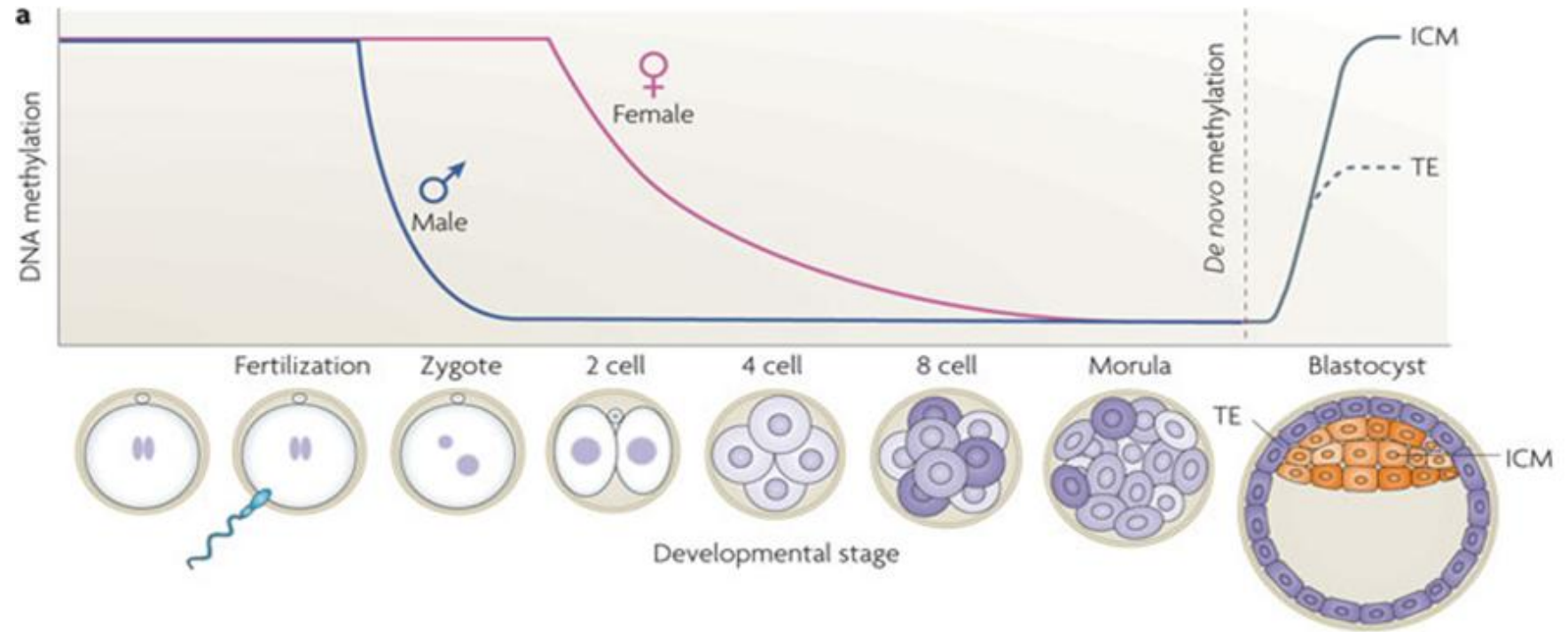
SUMO/ユビキチン修飾によるDNAの脱メチル化制御

（iPS化、クローン化、がん化）

SUMOによるクロマチン複製と修復制御

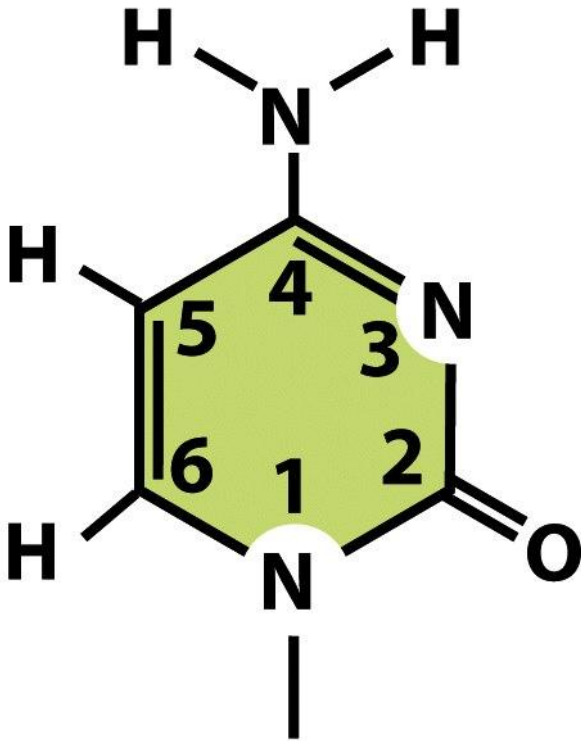
（ゲノム改変、老化、神経変性）

DNA脱メチル化によるエピゲノム制御



DNA methylation and demethylation

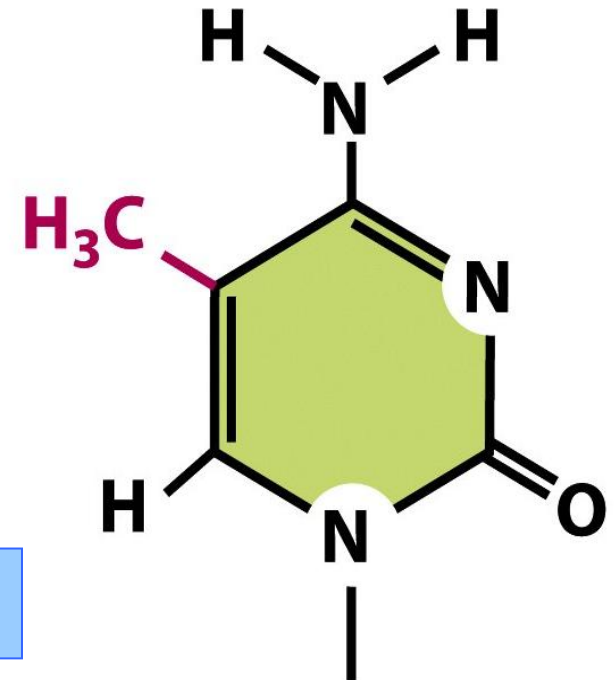
cytosine



methylation

DNMTs

5-methylcytosine



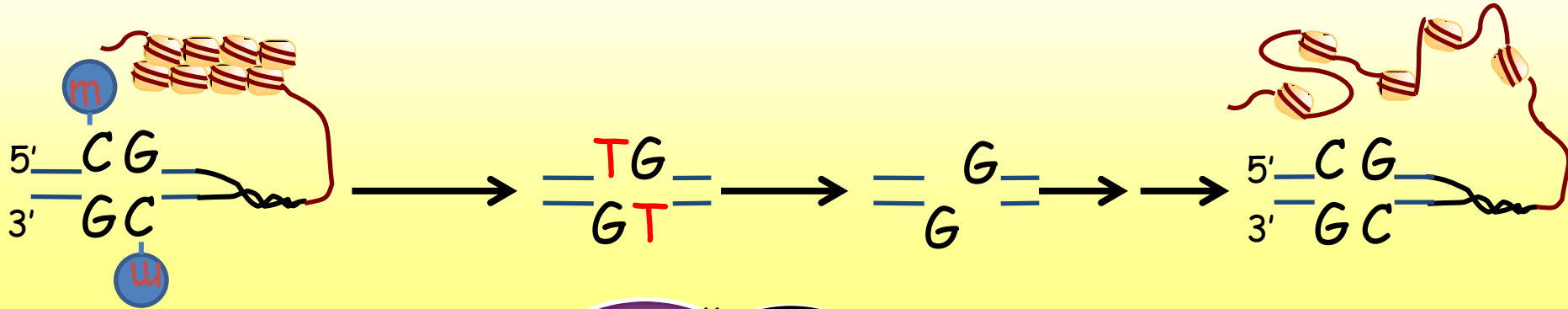
demethylation

遺伝情報の初期化

DNAの脱メチル化によるエピゲノム制御

Deamination/
Hydroxymethylation

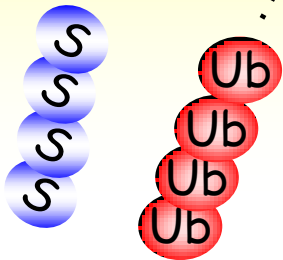
塩基除去修復



TDG^k RNF4

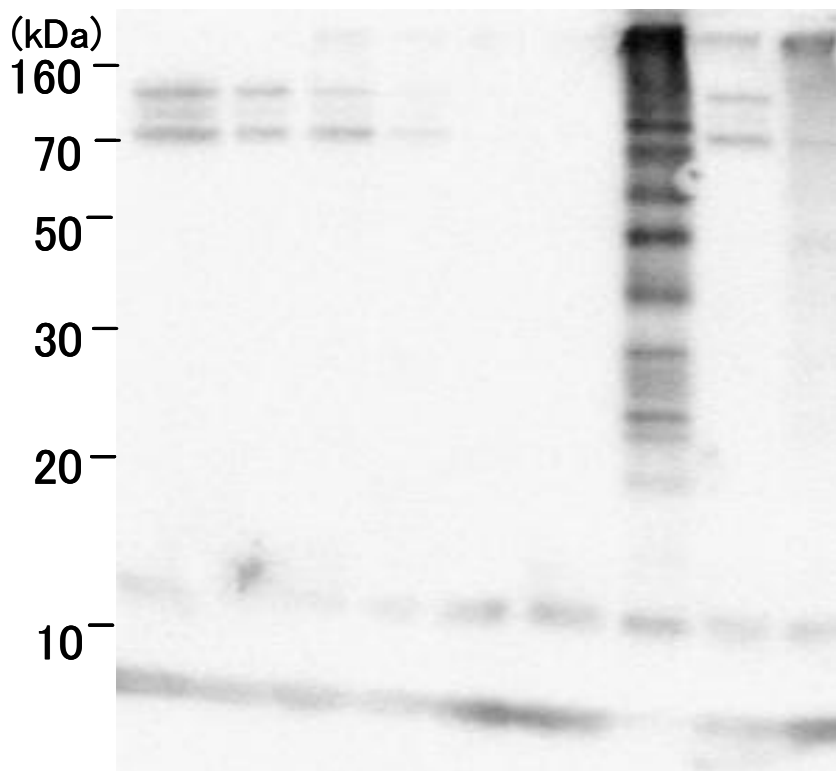
SUMO+
ユビキチン
依存的分解

proteasome

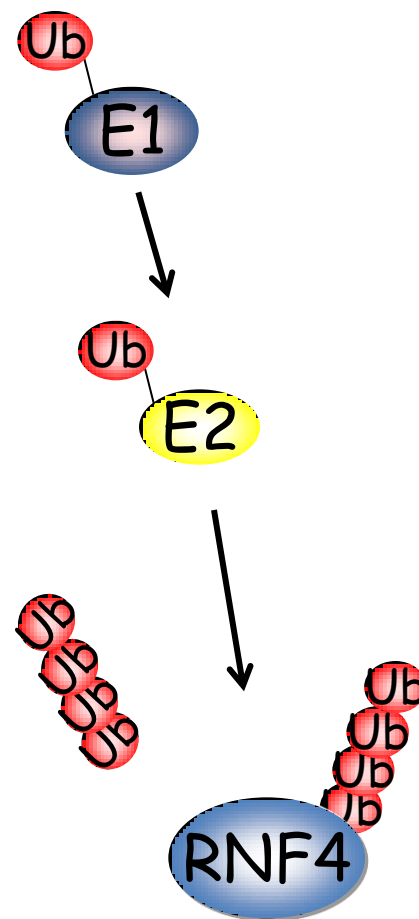


in vitro ユビキチン化反応の構築

Uba1	+	-	+	-	+	-	+	+	+
UbcH5a	-	+	+	-	-	+	+	+	+
His-RNF4	-	-	-	+	+	+	+	+	+
ATP	+	+	+	+	+	+	+	-	+
Mg ²⁺	+	+	+	+	+	+	+	+	-

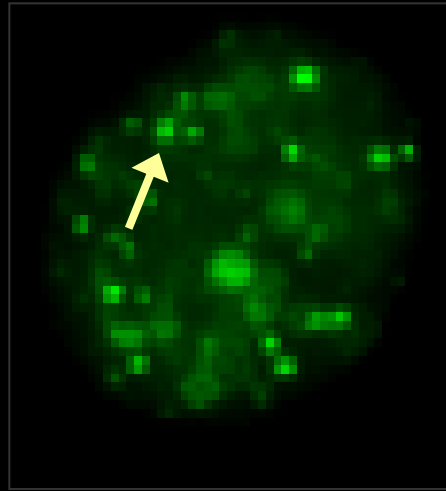


α Ubiquitin

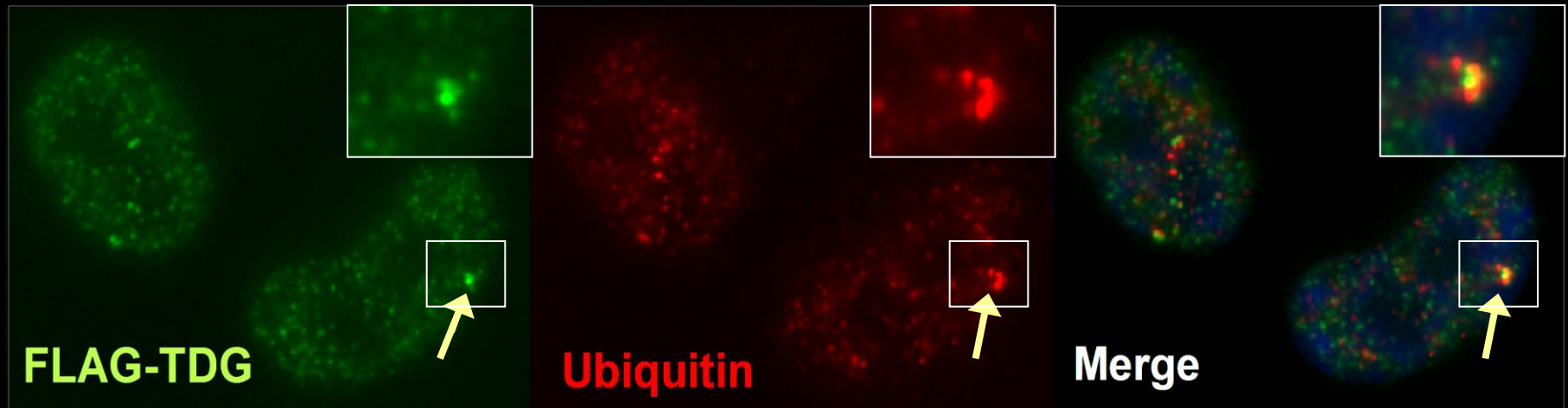
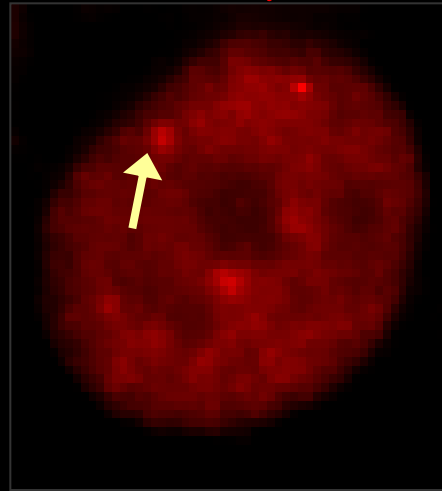


RNF4、TDGとユビキチンの局在観察

GFP-RNF4



HA-ubiquitin



FLAG-TDG

Ubiquitin

Merge

2011年メンバー（4月のお花見ピクニックにて）



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