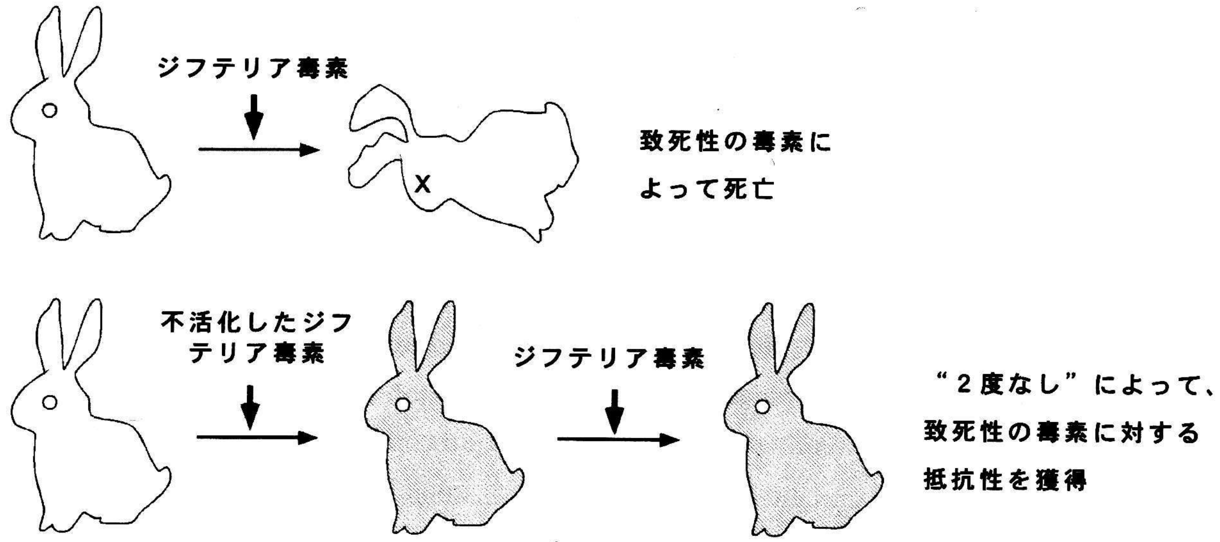
（Ⅲの続き）

〔2〕　ベーリングと北里柴三郎は、「2度無し」の本質を探るために以下の動物実験を行った。ウサギに活性型のジフテリア毒素を注射すると、ジフテリアを発症して死んでしまうが、予め「弱毒化した」ジフテリア毒素を注射しておいてから、活性型のジフテリア毒素を注射しても、「2度無し」のルールにより、ウサギはジフテリアを発症せず、死ぬこともなかった（図1）。北里らはこのとき、②「弱毒化したジフテリア毒素を先に投与すると、ウサギの血中でジフテリア毒素に対抗する何らかの物質ができる」ことにより、活性型のジフテリア毒素を注射してもジフテリアが発症しなくて済むようになっているとの仮説を立てた。



（図1）

問3．下線②に示す、この北里らの仮説を証明するためにはどのような実験を行えばよいか。実験方法とその結果から得られる結論を含めて、句読点を含めて150字以内で述べなさい。

（Ⅲの続き）

〔3〕　皮膚の傷害部位に侵入した外来異物は、まず樹状細胞によって捕捉される。異物を取り込んだ樹状細胞は、リンパ管を経て（1）へ到着し、樹状細胞が取り込んだ異物の情報をT細胞へと伝達する。この過程を（2）と呼ぶ。これを受けてT細胞は、この外来異物に対して攻撃を行うべきかどうかを判断し、攻撃を行う際には③別の種類のT細胞に直接攻撃させたり、B細胞に（3）を産生させる。④（3）は外来異物に結合し、その病原性を失活したり、T細胞に攻撃されやすくする働きがある。

樹状細胞やT細胞・B細胞などの免疫細胞は、（4）で誕生して分化するが、⑤T細胞は、ある分化段階で（5）へ移動し、ここで特殊な選別を受ける。これは、T細胞がどういった異物を敵として攻撃すべきかどうかの判断力をつけるための重要な過程である。

問4．（1）～（5）に適切な語句を埋めなさい。

問5．下線③、④で述べられている免疫作用をそれぞれ（A）性免疫、（B）性免疫と呼ぶ。（A）及び（B）に適切な語句を埋めなさい。

問6．下線⑤で述べられてあるように、免疫細胞の中でもT細胞のみが、特別な臓器で選別を受ける。この合目的性について考えられることを句読点を含めて100字以内で述べなさい。

Ⅳ．次の英文は、体表からの水分の喪失について、動物間で比較した研究に関するものである。本文を良く読んで、問１～問５に答えなさい。

Reptiles phylogenetically represent the first vertebrates to become truly terrestrial. In this study we have compared cutaneous and respiratory water loss in two species of turtles, two species of lizards, and one crocodilian, which represent three different evolutionary lines. We found large differences in both cutaneous and respiratory water losses which seem correlated with the environments in which these animals usually live.

①<u>Evaporation was estimated from weight loss of the animal with a correction for weight loss due to metabolic loss of carbon.</u> Urine and fecal losses were either prevented by taping or measured by cannulating the cloaca. Weight loss from the head (principally respiratory tract) and from the rest of the body (skin) was measured separately by keeping the body in a polyethylene bag (thickness, 0.1 mm), containing a desiccant to prevent possible diffusion loss of water, which was sealed around the neck with adhesive tape. Water loss from the head was obtained by placing the animal in a plastic chamber, passing dry air slowly over the animal, and then determining the weight loss. By subtracting the loss-of carbon (CO_2 estimated from the metabolic rate) and the water loss from the skin of the head (using the mean rate of cutaneous water loss determined separately), respiratory water loss was obtained.

Cutaneous water loss was determined as the difference between total weight loss and respiratory water loss as obtained in alternate experiments on the same animal. ②<u>The surface area of the animals was calculated from the equation: area (cm^2) = 10 body weight (grams).</u> Oxygen consumption was determined in an open system where air was passed over the animals at a constant rate and change in partial pressure of oxygen was determined with a Beckman paramagnetic oxygen analyzer. After an equilibration period of 1 to 3 hours, values were recorded at 15-minute intervals for 1 hour, and the mean value was used.

Total water loss varied considerably in the different reptiles. For example, water loss per surface area was 19 times as high in the crocodilian *Caiman sclerops* as in the desert lizard *Sauromalus obesus* (Table 1, column a). The figures represent total weight loss (excluding excreta), but subtraction of metabolic carbon (about 0.5 percent of the total in *Caiman* and about 10 percent in *Sauromalus*) would not materially change the relation. In all species examined, water loss shows a conspicuous correlation with habitat, decreasing drastically with increasing aridity.

（Ⅳの続き）

The importance of water loss to an animal is perhaps more evident if we consider the loss that is sustained over a 24-hour period. Calculated as the percentage of body weight evaporated per 24 hours, the figures (corrected for metabolic carbon) would be: *Caiman* 11.5, *Pseudemys* 2.0, *Terrapene* 0.9, *Iguana* 0.8, and *Sauromalus* 0.3 percent. While the *Caiman* lost one-tenth of its body weight by evaporation in a day, it would take *Sauromalus* about __(A)__ days to reach the same degree of dehydration. Respiratory weight loss also shows a trend correlated with the habitat of the animal. However, it seems more meaningful to relate respiratory water loss to oxygen consumption because evaporation from the lungs should increase with increasing oxygen consumption (Table 1, column [ア]).

Respiratory water loss of reptiles is surprisingly high as compared to that in mammals. Only in the two lizards is it similar to the figure for man, whose respiratory evaporation is about 0.85 mg of H_2O per milliliter of O_2, and to the range of total evaporation in a variety of small nonsweating rodents where it may be as low as 0.5 mg of H_2O per milliliter of O_2.

Cutaneous water loss also decreases successively with aridity of the habitat. In the crocodilian *Cairnan sclerops*, cutaneous water loss was of an order of magnitude about one-third of the water loss from the skin of amphibians. This is surprising in view of the common belief that the skin of reptiles is essentially impermeable to water.

The role of cutaneous water loss in total evaporation from these reptiles is given in the column [イ] of Table 1. It is astonishing to find that in all the reptiles that we examined cutaneous evaporation was two-thirds or more of the total evaporation. At a higher temperature respiratory evaporation can be expected to increase because of increased metabolism and because warm air can contain more water vapor. Cutaneous evaporation should also increase and was found to do so in about the same proportion as the increase in vapor pressure.

（出典：P. J. Bentley, Knut Schmidt-Nielsen, *Science* 151:1547-1549 (1966) より抜粋）

※本文に使用されている専門性が高い用語

reptile 爬虫類　／　lizard トカゲ　／　cutaneous 皮膚の　／　crocodilian ワニ類
cloaca 総排出腔　／　desiccant 乾燥剤　／　excreta 排泄物　／　aridity 乾燥状態
rodents 齧歯類　／　amphibians 両生類

（Ⅳの続き）

Table 1.　Respiratory and cutaneous water loss in various reptiles in dry air at 23℃. Results are expressed as means ± S.E.

		Column a	Column b	Column c	Column d	Column e	Column f	Column g
Number of animal	Body weight (g)	Total weight loss (mg / cm^2/ day)	Oxygen consumption (ml/g/day)	Respiratory			Cutaneous	
				Weight loss (mg/g/day)	Weight loss (mg/ml O_2)	Water loss (mg/ml O_2)	Water loss (mg/cm^2/day)	Water loss (% of total)
				（　動物種名１　）				
8	124	37.7±2.11	1.8±0.05	9.6±1.2	5.3±0.91	4.9	32.9±2.45	87±2.1
				Pseudemys scripta				
6	600	15.8±1.70	0.9±0.12	4.3±0.48	4.7±0.88	4.2	12.2±1.44	78±2.7
				Terrapene Carolina				
6	305	7.2±0.31	0.6±0.05	2.6±0.29	4.6±0.53	4.2	5.3±0.41	76±3.4
				Iguana iguana				
8	124	6.7±0.41	2.6±0.36	3.4±0.48	1.3±0.21	0.9	4.8±0.50	72±4.3
				（　動物種名２　）				
6	134	2.0±0.168	1.2±0.96	1.1±0.05	0.9±0.08	0.5	1.3±0.10	66±2.0

問１．Table 1 中の（　動物種名１　）、（　動物種名２　）を本文から見つけて、記入しなさい。

問２．下線①について、water loss の程度を推定するため、metabolic loss of carbon をどのように推定しているか、日本語で句読点を含めて 100 字以内で述べなさい。

問３．下線②は、体表の総面積を推定する方法について記載されたものである。
　この研究では、なぜ体表の面積を求める必要があるのか、日本語で句読点を含めて 100 字以内で述べなさい。

問４．(A) に適切な数字を記入しなさい。

問５．［ア］と［イ］に適切なアルファベットを記入しなさい。