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群馬大学

後期日程

見本

受験番号	

医学部医学科小論文問題

注 意 事 項

1. 試験開始の合図があるまで問題冊子を開いてはいけません。

2. この問題冊子のページ数は14ページです。問題冊子，答案用紙及び下書き用紙に，落丁，乱丁，印刷不鮮明などの箇所がある場合は申し出てください。

3. 解答は指定の答案用紙に記入してください。

(1) 文字はわかりやすく，横書きで，はっきりと記入してください。

(2) 解答の字数に制限がある場合には，それを守ってください。

(3) 訂正，挿入の語句は余白に記入してください。

(4) ローマ字，数字を使用するときは，ます目にとらわれなくてもかまいません。

4. 試験時間は90分です。

5. 答案用紙は持ち帰ってはいけません。

6. 問題冊子と下書き用紙は持ち帰ってください。

次の文章を読んで設問A～Fに答えなさい。文末に，*印のついた単語の訳注があります。

The structure of explanation of development as an unfolding of a predetermined genetic program has powerful consequences for the explanation of the manifest variation among organisms. Although developmental biology is not primarily concerned with variation, the existence of variation among individuals enters into the program of investigation in a special way through the use of gene mutations that have drastic effects on development. The standard method for showing that a gene is important in, say, the development of wings in an insect, is to find a mutation of the gene that prevents wings from being formed or, even more interesting, that results in the formation of extra wings. (A) The use of drastic gene mutations as the primary tool of investigation is a form of reinforcing practice that further convinces the biologist that any variation that is observed among organisms must be the result of genetic differences. This reinforcement then carries over into biological theory in general.

While observations of the natural variation between individuals are not taken into account in building the theory of development, the existence of such variation is obvious to all. Especially in the human species this variation may have great individual and social consequences. Differences in temperament, in the possession of particular physical and mental abilities, in health and disease, in social power all demand explanation. Up until the Second World War biologists, especially geneticists, were for the most part biological determinists who ascribed* to genes the chief causal influence in molding social, psychological, and cognitive differences between individuals. Then, as the consequences of the biological theories of race and character in hands of the National Socialists* became widely known, there was a general revulsion* against biological determinism and it was replaced by a widespread environmentalist explanation of social facts. But this environmentalist dominance was short-lived, and within twenty years of the end of the war, genetic explanations again came to dominate, in no small part because psychology and sociology failed to produce a coherent predictive scheme for human psychic and social development.

The reigning mode of explanation at present is genetic. Reinforced by the observation that some human disorders result from mutation of clearly defined genes, nearly all human variation is now ascribed to genetic differences. From the undoubted fact that gene mutations like the Tay-Sachs* mutation or chromosomal abnormalities like the extra chromosome* causing Down syndrome* are the sources of pathological variation, human geneticists have assumed that heart disease, diabetes*, breast cancer, and bipolar syndrome* must also be genetic variants. The search for genetic variation underlying widespread human disease conditions is a major preoccupation of medical research, a major consumer of publicly funded research projects, and a major source of news articles on health. Nor is it only pathological variation that is explained genetically. Variations in sexual preference, in school performance, in social position are also seen as consequences of genetic differences. If the development of an individual is the unfolding of a genetic program immanent* in the fertilized* egg, then variations in the outcome of development must be consequences of variations in that program.

(B) The trouble with the general scheme of explanation contained in the metaphor of development is that it is bad biology. If we had the complete DNA sequence of an organism and unlimited computational power, we could not compute the organism, because the organism does not compute itself from its genes. Any computer that did as poor a job of computation as an organism does from its genetic "program" would be immediately thrown into the trash and its manufacturer would be sued by the purchaser. Of course it is true that lions look different from lambs and chimps from humans because they have different genes, and a satisfactory explanation for the differences between lions, lambs, chimps, and us need not involve other causal factors. But if we want to know why two lambs are different from one another, a description of their genetic differences is insufficient and for some of their characteristics may even be irrelevant. Even a very faulty computer will be satisfactory if one is only interested in calculations to an order of magnitude, but for accuracy to one decimal place* a different machine is needed. (C) There exists, and has existed for a long time, a large body of evidence that demonstrates that the ontogeny* of an organism is the consequence of a unique interaction between the genes it carries, the temporal sequence of external environments through which it passes during its life, and random events of molecular interactions within individual cells. It is these interactions that must be incorporated into any proper account of how an organism is formed.

First, although internally fixed successive developmental stages are a common feature of development, they are not universal. A striking case is the life history pattern of certain tropical rain forest vines* (see Figure 1). After the seed germinates* on the forest floor, the shoot* grows along the ground toward any dark object, usually the trunk of a tree. At this stage the plant is positively geotropic* and negatively phototropic*. If it encounters a small log it grows over it, putting out leaves (form T_L), but then continues to grow along the ground without leaves (form T_S). When it reaches a tree trunk it switches to being negatively geotropic and positively phototropic and begins to climb the trunk away from the ground and toward the light (form A_A). As it climbs higher more light reaches its growing tip, and it begins to put out leaves of a particular shape at characteristic intervals along its growing stem. As it grows higher and yet more light falls on it the leaf shape and distance between leaves changes, and at a sufficient light intensity it begins to form flowers. If a growing tip grows out along a branch of the tree it becomes again positively geotropic and negatively phototropic, changes its leaf shape and spacing, and forms an aerial* vine that grows down toward the ground (form A_D). When it reaches the ground it again returns to the T_S form until it encounters another tree, and there it may climb even higher in form A_A, as shown on the right in Figure 1. Each pattern of leaf shape, leaf spacing, phototropism, and geotropism is dependent on the incident light conditions, and there is no internally fixed order of stages. Even the description of the stages is somewhat arbitrary, since the shape and spacing of leaves change continuously as the stem ascends the tree trunk.

It might be that such switching among growth patterns under the influence of environment would be possible only in plants, because they have embryonic* tissue at their growing points throughout their entire lives. However, the same phenomenon can be seen in the regulation of differentiation in insects. The wing of a moth develops from a lump of tissue, the wing imaginal disc*, during the development of the adult inside the pupal* case. The wing imaginal discs are generally considered to be independent of the discs that develop into the head or legs or abdomen* or genitalia*. Nevertheless, if a wing disc is wounded, the development of all parts of the organism ceases while the wound in the wing disc is repaired, and then development of the whole organism resumes.

Second, the organism is not specified by its genes, but is a unique outcome of an ontogenic process that is contingent on the sequence of environments in which it occurs. This can be illustrated by the famous experiments of Jens Clausen, David Keck, and William Heisey on plants from different environments. These experiments took advantage of the fact that in some plants it is easy to clone* genetically identical individuals by the simple process of cutting a plant into pieces, each one of which will grow into a new complete individual. A sample of the plant *Achillea millefolium** was taken and each plant was cut into three pieces. One piece was planted at a low elevation, 30 meters above sea level, one at an intermediate elevation in the foothills of the Sierra Nevada mountains at 1,400 meters, and one at a high elevation, 3,050 meters, in the mountains. The three plants that grew from the three pieces of the original plant are then genetic clones of each other developing in three different environments. The result of the experiment for seven different plants is shown in Figure 2.

The seven different genetic strains that were sampled are shown horizontally, arranged in order of how well they grew at the lowest elevation. The three plants in a vertical row are the plants that grew from the three cloned pieces from a single plant in the three different environments. We see immediately that it is not possible to predict the order of growth in the medium or high elevation from the order at the lowest elevation. The plant that grew best at the lowest elevation also had the best growth at the highest elevation, but at the medium elevation it was the poorest plant and failed to flower. The second-best-growing plant at high elevation was next to the worst at low elevation and in the middle of the growth range at intermediate elevation. In general, there is no way of predicting the growth order from one environment to another. There is no correlation of growth pattern from one environment to another. It is not possible to ask the question, "Which genotype* caused the best growth," without specifying the environment in which the growth occurred. Even averaging over the environments is not very informative. Genotype 5 (average=25cm) and genotype 7 (average=18cm) grew more poorly on the average over the environments, but the averages of the other five genotypes were indistinguishable (32—33cm), even though each grew very differently in each environment. It is important to note that Figure 2 does not portray an extreme example. The experiments involved many such comparisons, and all showed similar results.

The experiment in Figure 2 can be represented in a graphical form that summarizes the results. In Figure 3 plant height for each genotype is plotted against the elevation at which it grew. Such graphs, giving the *phenotype* (physical properties) of organisms of a particular genotype as a function of the environment, are called *norms of reaction*. A norm of reaction is the mapping of environment into phenotype that is characteristic of a particular genetic constitution. So a genotype does not specify a unique outcome of development; rather it specifies a norm of reaction, a pattern of different developmental outcomes in different environments. The norms of reaction in Figure 3 are typical of what is seen in such experiments. There are occasional genotypes like genotype 7 whose norm of reaction lies below others in all environments. But most genotypes have norms of reaction with complex patterns that cross each other in unpredictable ways. The norm of reaction for genotype 3 decreases monotonically* with increasing altitude. Genotype 4 has a maximum at the intermediate altitude while genotype 1 shows a very pronounced minimum at this altitude.

Results like these are not peculiar to *Achillea* or to plants. Figure 4 shows a similar experiment in the fruit fly, *Drosophila melanogaster**. It has so far not been possible to clone *Drosophila* in order to make a large number of individuals of identical genotype, but by genetically marking their chromosomes and making specially designed crosses between marked strains it is possible to produce very large numbers of individuals whose genotype is identical for large sections of the genome. Different genetic strains isolated from natural populations of *Drosophila* can then be compared in different environments. Figure 4 shows the survivorship* from egg to adult of various genotypes taken from a population of *Drosophila* when the immature stages develop at different temperatures. [D]

The importance of taking into account the norm of reaction of a genotype is well recognized in plant breeding. New commercial varieties of cultivated plants, for example new maize* hybrids, are tested for yield in several years and on farms from different areas in the region where the crop will be grown. Varieties are chosen for release to farmers partly on the basis of their average productivity over years and locations, but also for their uniformity of production over time and space. A hybrid that shows a high average because it is highly superior in a particular year or location, but that otherwise gives a somewhat lower yield than other varieties, will not be selected for release. Seed companies are concerned less with average yield than with reliability of that yield in varying environments, because it is on that basis that farmers will choose the seed to purchase. As a consequence of this policy of plant breeding, (E) <u>there has been an evolution of the norms of reaction of commercial hybrid maize to become flatter and flatter, responding less and less to changes in environment.</u> Figure 5 shows a comparison of the norms of reaction of a maize hybrid of the 1940s (Variety 1) and a commercial hybrid from the 1960s (Variety 2), determined in an experiment that compared these different genotypes in a common set of years and locations. In fact, in the best environment the old hybrids were better than the newer ones, but they were more sensitive to different environments and so were replaced by the less environmentally sensitive genotypes.

(Richard Lewontin 著 "The Triple Helix" Harvard University Press より一部改変)

*訳　注

1. 本文

ascribe：(結果などを)・・・のせいにする
National Socialists：国家社会党員，ナチス
revulsion：嫌悪感
Tay-Sachs：テイーサックス病
chromosome：染色体
Down syndrome：ダウン症候群
diabetes：糖尿病
bipolar syndrome：双極症候群
immanent：内在する
fertilize：受精させる
decimal place：小数位，小数点以下の桁数
ontogeny：個体発生
vine：つる植物
germinate：発芽する
shoot：若枝，若木
geotropic：重力屈性，向地性
phototropic：光屈性，屈光性
aerial：空気中で生長する
embryonic：未発達の，未熟な，胚性

imaginal disc：成虫原基

pupal：蛹(さなぎ)の

abdomen：腹部

genitalia：性器

clone：クローン(名詞)，クローンとして発生させる(動詞)

Achillea millefolium：セイヨウノコギリソウ

genotype：遺伝子型

monotonically：単調に

Drosophila melanogaster：キイロショウジョウバエ

survivorship：生存率

maize：トウモロコシ

2. 図

morphology：形態学

Syngonium：シンゴニウム(サトイモ科の植物)

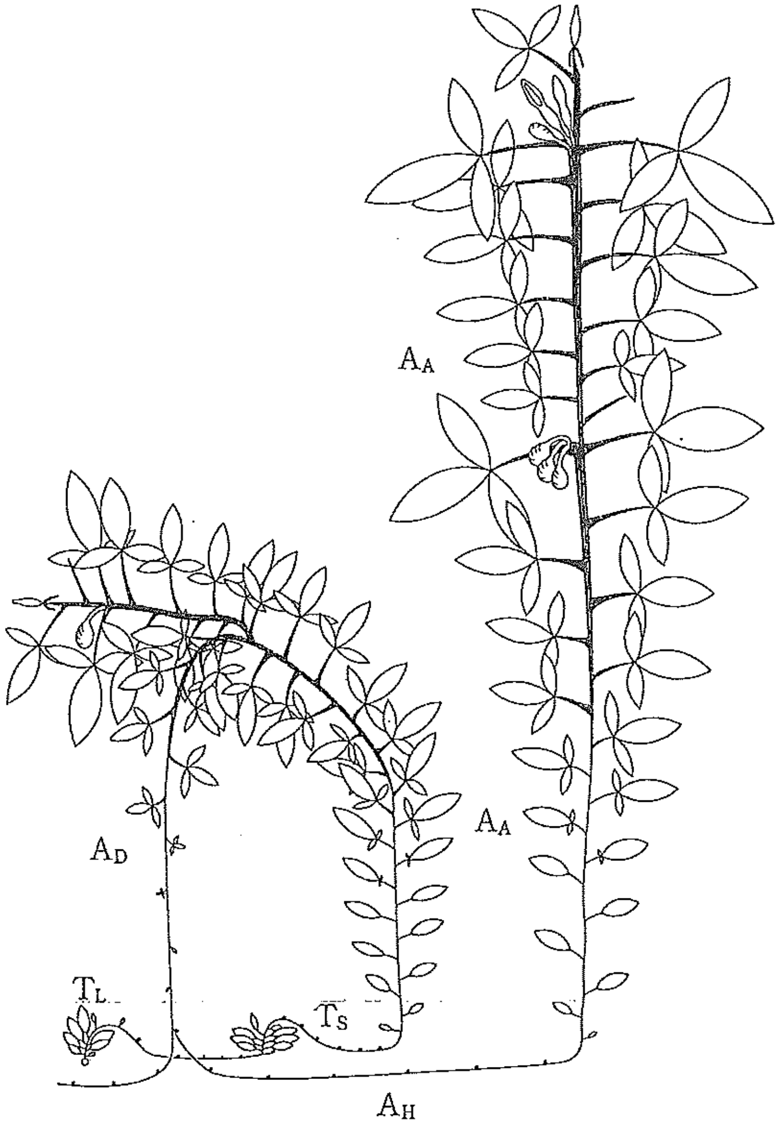

Figure 1. Changes in the morphology* of the tropical vine *Syngonium** as it grows. T_L and T_S are terrestrial patterns, A_A is the pattern as it ascends a tree, A_D is the pattern when it is descending from a branch toward the ground.

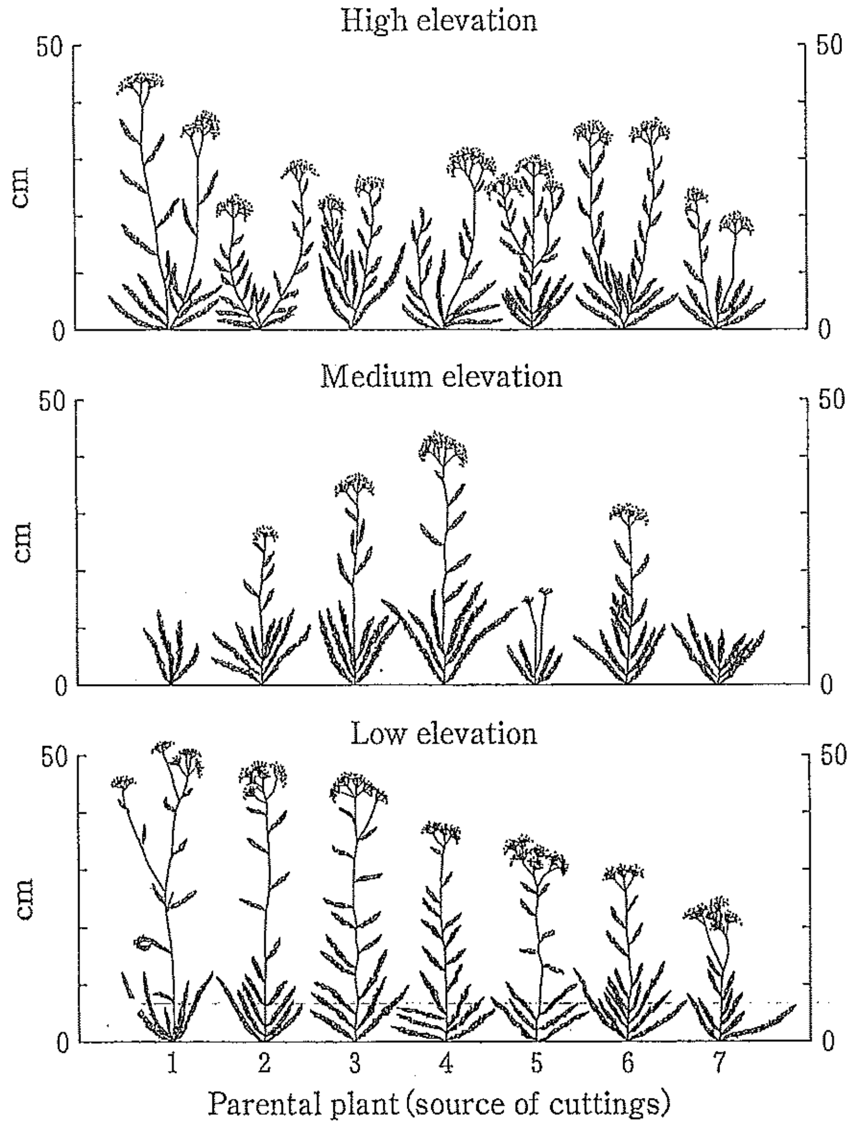

Figure 2. Growth of clones of seven genetically different plants of *Achillea* grown at three different elevations.

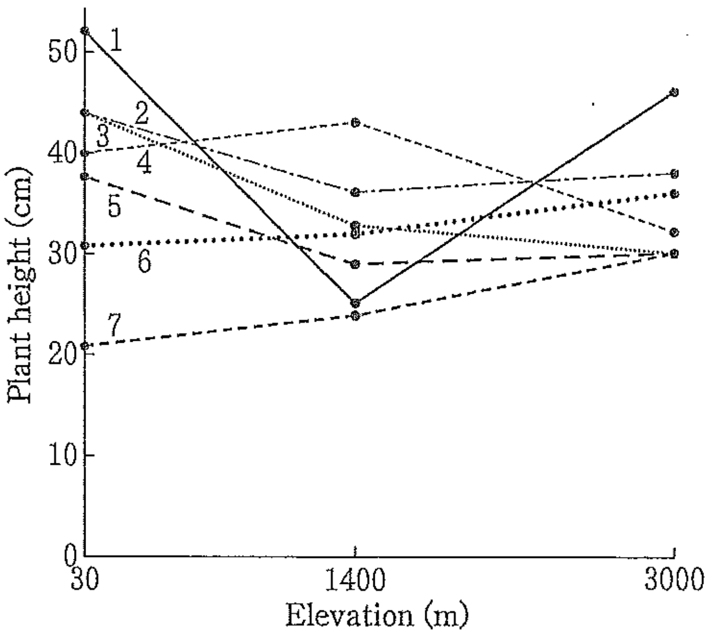

Figure 3. A graphical representation of the heights of the seven plants shown in Figure 2, at the three different elevations.

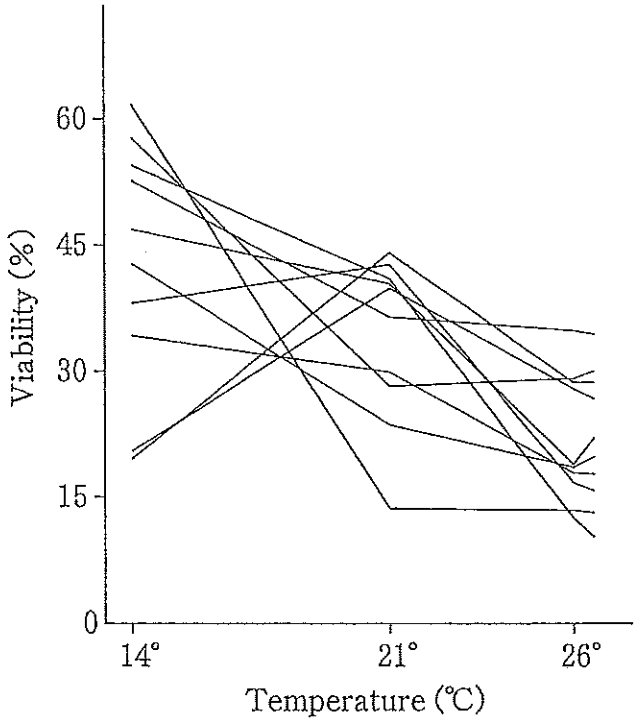

Figure 4. The viability of ten different genotypes of *Drosophila* when tested at three different temperatures.

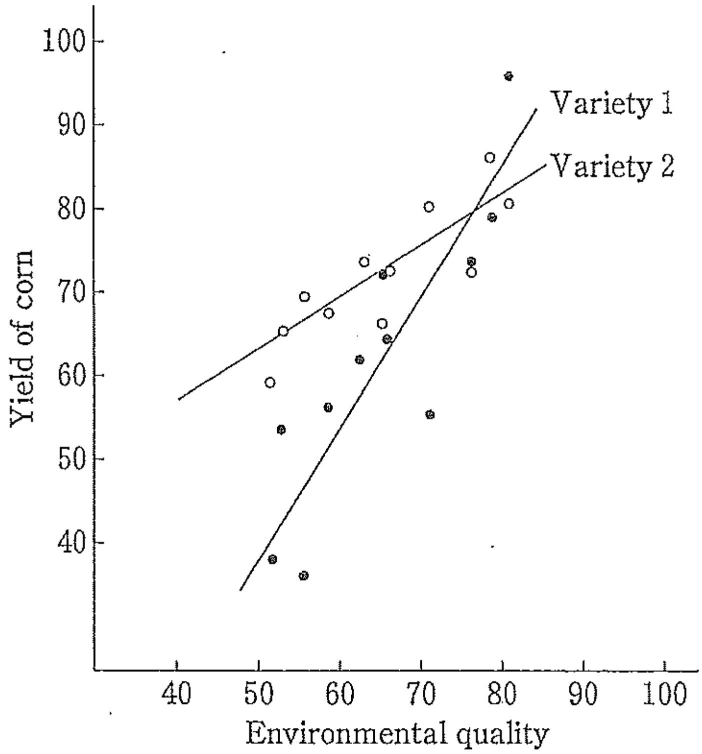

Figure 5. The yield of seed from a maize hybrid used in the United States in the 1940s (Variety 1) and a commercial hybrid of the 1960s (Variety 2) when tested in different years and different localities that were rated according to environmental quality.

設　問

A．下線(A)はどのようなことか，答案用紙 [1—1] のA欄に日本語150字以内(句読点を含めて)で説明しなさい。

B．下線(B)はどのようなことか。答案用紙 [1—1] のB欄に日本語300字以内(句読点を含めて)で説明しなさい。

C．下線(C)はどのようなことか。答案用紙 [1—2] のC欄に日本語200字以内(句読点を含めて)で説明しなさい。

D．空欄 [D] にはFigure 4の説明が述べられている。*Achillea millefolium* の結果との類似点および相違点に関する比較を行い，Figure 4から読み取れることを答案用紙 [1—2] のD欄に日本語200字以内(句読点を含めて)で説明しなさい。

E．下線(E)はどのような理由によるものか。答案用紙 [1—3] のE欄に日本語200字以内(句読点を含めて)で説明しなさい。

F．本文の原題 "The Triple Helix" にはどのような意味が込められているか。答案用紙 [1—3] のF欄に日本語100字以内(句読点を含めて)で説明しなさい。