Supplemental Material

CBE—Life Sciences Education

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Supplemental materials

Full description of tasks:

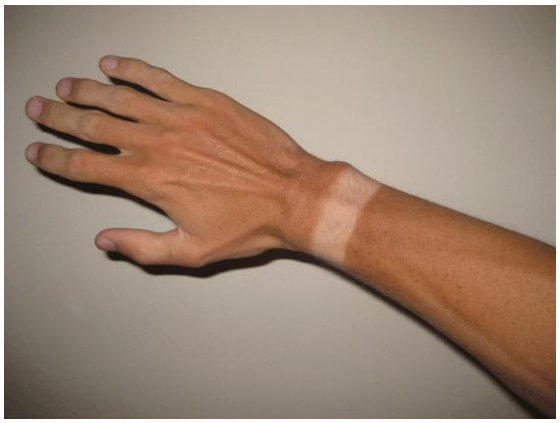
Tanning Task

Look at this picture showing darker skin as a result of exposure to sun.

Is tanning a genetic trait?

How does the environment influence skin color?

- How does this work, please explain the mechanism at the level of the cell?
- Do proteins/genes have anything to do with this phenomenon?



Stunting Task

Here is another phenomenon called stunting. Children who are malnourished tend to be less tall than their potential (compared to their age group and calculated potential based on their parents' height).

- Is stunting a genetic trait?
- Does the environment have an impact on height?
- How does that work? Explain at the level of the tissue and cell
- Do proteins/genes have anything to do with this phenomenon?
- Do you think this effect will persist to the next generation?

Trans generational stunting task

It turs out from various studies that the stunting effect persist to the next generation (even if the nutritional conditions are fine). How does that work?

Smell Imprinting task

Worm larvae exposed to an environment with good food that has a specific smell become attracted to this smell. When the become adults, they also lay more eggs in response to the smell (even if there is no food). This is called smell imprinting. Offspring of worms that were imprinted on a specific smell also show the same behavior of attraction and increased egg laying even if they were not exposed to the smell as larvae.

Is olfactory imprinting a genetic trait?
How does the environment impact attraction to a smell and increased egg laying?
How is it possible that this is inherited as an acquired trait?
Do proteins/genes have anything to do with this phenomenon?

Task analysis

The four tasks involve phenotypic plasticity at a certain level: The tanning task represents a transient response to UV radiation that may be explained by inhibiting/activating cellular mechanisms (inhibiting/activating proteins) or regulation of gene expression on translation or on protein degradation. The first stunting task represents a long-term response to a lack of nutrients which may be explained by regulation of gene expression (on translation or on protein degradation), the trans generational stunting task and the smell imprinting tasks represent a trans generational epigenetic effect.

As mentioned in the main text students were not expected to provide the actual scientific explanation to the phenomenon but a biologically plausible one (see methods). Hence a correct answer should include:

1. Identifying the triggering environmental factor – an entity that triggered the process (e.g sunlight/UV radiation, lack of sugar/nutrients, smell molecule/odorants)
2. Identifying a plausible entity for detecting this environmental factor - sensing organ, sensing protein/receptor (e.g. a photoreceptor, UV sensing protein, blood sugar receptor, brain, nervous system, nose)
3. Identifying a plausible entity for signaling - a change in the sensing entity, hormone, signaling molecule (e.g. a structural change in a protein activates a cascade, hormone secretion)
4. Identifying a plausible response - inhibiting/activating a mechanism (e.g. inhibiting or activating mechanisms for skin color production/ growth/ movement toward a specific direction, regulation of gene expression by transcription factors or epigenetic modification/translation/protein degradation)
5. Linking between the response mechanism to the final phenotype

*It should be noted that step 2,3 and some of 4 can be merged in simple molecular mechanisms. It these cases the sensing entity directly triggers the respose. For example, in the Lac operon system the repressor protein is both sensing the environment (Cellular levels of Lactose) and activating transcription by detaching from the DNA as a result of Lactose.