Amphibian Metamorphosis

Morphological changes

Aquatic existence ⟶ terrestrial existence

Urodeles

resorption of the tail fin

the destruction of the external gills

change in skin structure

Anurans

More complicated

Every organ is subject to modification

Larval structures respond to T4 and T3 in four ways

growth, death, remodeling, and respecification

Growth of New Structures

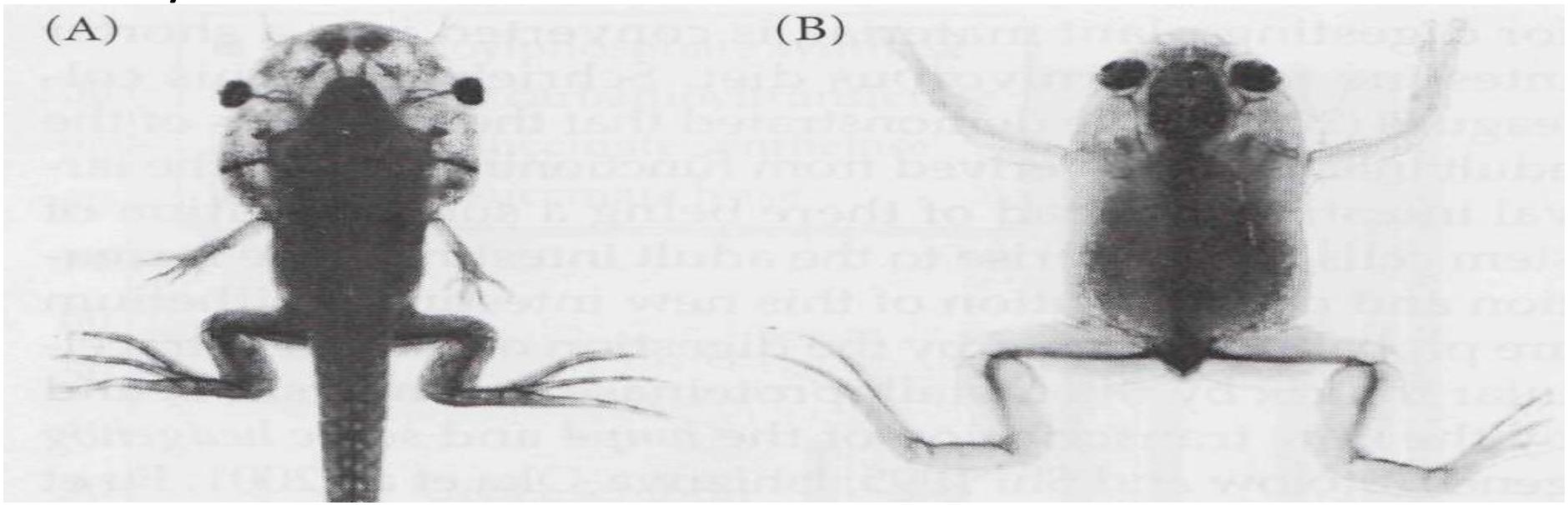
The limbs, nictitating membranes and eyelids emerge

T3 induces the proliferation and differentiation of new neurons to serve these organs

Blocking T3 activity prevents these neurons from forming and causes paralysis of the limbs

Eyes move to the front of the head from their originally lateral position

Ipsilateral pathways emerge, enabling input from both eyes to reach the same area of the brain



Cell Death during Metamorphosis

T3 causes the degeneration of the paddle-like tail and the oxygen- procuring gills

First part of tail resorption is caused by suicide, but that the last remnants of the tadpole tail must be killed off

T3 tells the muscle cells to kill themselves by apoptosis

Later in metamorphosis, the tail muscles are destroyed by phagocytosis

Larval red blood cells are specifically digested by macrophages in the liver and spleen

Remodeling during Metamorphosis

Larval intestine is converted into a shorter intestine for a carnivorous diet

Much of the nervous system is remodeled as neurons grow and innervate new targets

The lateral line system of the tadpole degenerates, and the ears undergo further differentiation

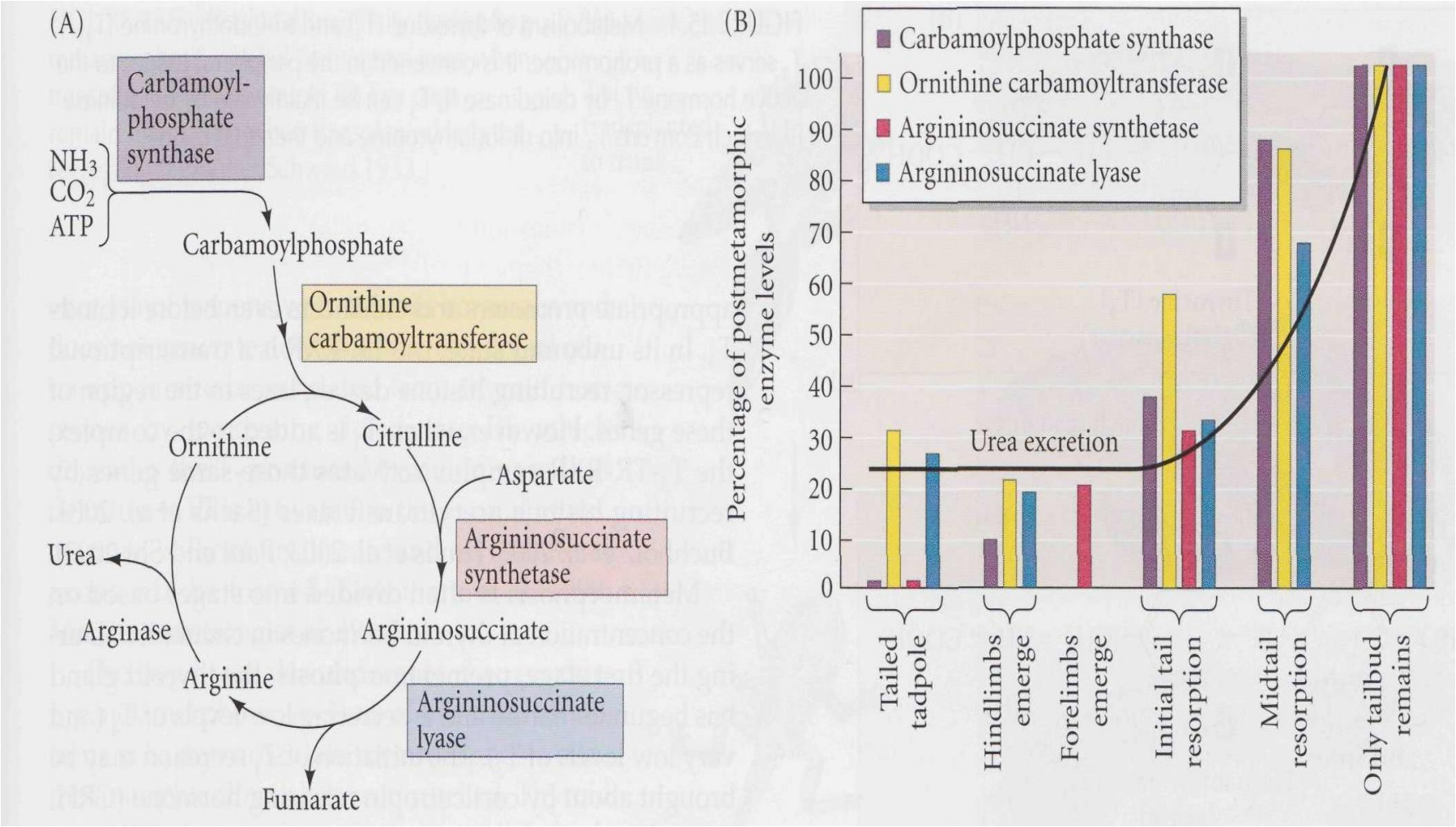
The middle ear develops, as does the tympanic membrane characteristic of frog and toad outer ears

Tadpoles experience a brief period of deafness as the neurons change targets

The shape of the anuran skull also changes significantly

Biochemical Respecification

Ammonotelic → ureotelic



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Hormonal control of amphibian metamorphosis

Metamorphic changes are due to

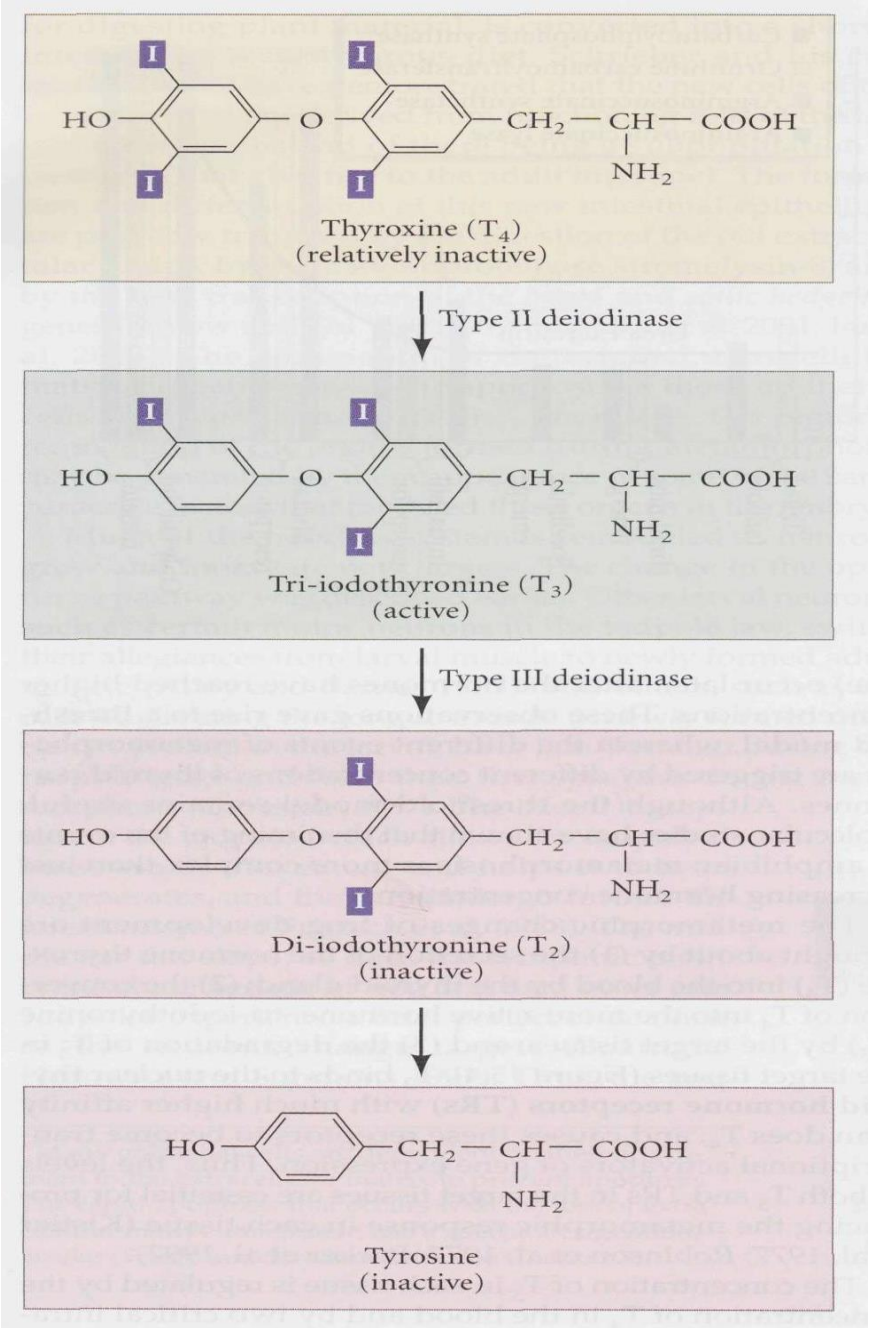
1. the secretion of the hormone thyroxine (T4)
2. the conversion of T4 into the more active hormone, tri-iodothyronine (T3)
3. the degradation of T3 in the target tissues

T3 binds to the nuclear **thyroid hormone receptors (TRs)**

Thus T3 and TRs are essential in each tissue

Conc. of T3 depends on T4 and two imp. Enzymes

1. Type II deiodinase removes an iodine atom from the outer ring of the precursor hormone (T4) to convert it into the more active hormone T3
2. Type III deiodinase removes an iodine atom from the inner ring of T3 to convert it into an inactive compound that will eventually be metabolized to tyrosine



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Receptor types

Two types

1. TR α 2. TR β

TR α is widely distributed and is present before the organism has a thyroid gland

TR β is gene product which is activated by hormone

TR binds and forms dimer with RXR. These dimers bind T3 and effect transcription

TR-RXR is associated with gene promoters and enhancers and repress transcription

When T3 added to this complex, gene activation takes place

Premetamorphosis

During this stage the thyroid gland has begun to mature and is secreting low levels of T4

The initiation of T4 secretion may be brought about by corticotropin releasing hormone (CRH)

CRH may act directly on the frog pituitary, instructing it to release thyroid stimulating hormone (TSH), or it may act generally to make the body cells responsive to low amounts of T3

The tissues that respond earliest to the thyroid hormones are those that express high levels of deiodinase II, and can thereby convert T4 directly into T3

As the thyroid matures to the stage of prometamorphosis, it secretes more thyroid hormones

Many major changes (such as tail resorption, gill resorption, and intestinal remodeling) must wait until the **metamorphic climax** stage

The concentration of T4 rises dramatically, and TRβ levels peak inside the cells

Prometamorphosis

During prometamorphosis, the rising levels of thyroid hormones induce higher levels of TRβ

At metamorphic climax, deiodinase II is expressed, and the tail begins to be resorbed

Thus the tail undergoes absorption only after the legs are functional

The frog brain also undergoes changes during metamorphosis, and one of the brain's functions is to downregulate metamorphosis once metamorphic climax has been reached

Thanks